Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania

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U.S. Environmental Protection Agency
Region 3
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Table of Contents

List of Tables

List of Figures

Executive Summary

The Wissahickon Creek drains approximately 64 square miles and extends 24.1 miles in a southeasterly direction through lower Montgomery and northwestern Philadelphia Counties. The Wissahickon Creek is designated for trout stocking, and is subject to all water quality criteria specific to this designated use and those defined for general statewide water uses including aquatic life, water supply, and recreation. As a result of biological investigations conducted by the Pennsylvania Department of Environmental Protection (PA DEP) that identified observed impacts on aquatic life, much of the Wissahickon Creek basin has been listed on the State's 303(d) list of impaired waters. The watershed is heavily impacted by urbanization and is listed as impaired due to problems associated with elevated nutrient levels, siltation, low dissolved oxygen concentrations, chlorine, water/flow variability, oil and grease, and pathogens.

The Environmental Protection Agency Region III (EPA) establishes these Total Maximum Daily Loads (TMDLs) for the Wissahickon Creek basin to address those stream segments impaired as a result of excess nutrients and siltation. To address nutrient impairments, TMDLs have been established for ammonia nitrogen (NH3-N), nitrate-nitrite nitrogen (NO3+NO2-N), ortho phosphate (ortho PO4), and carbonaceous biochemical oxygen demand (CBOD) in order to attain and maintain applicable Water Quality Standards (WQS). There are presently no nutrient nor siltation criteria defined by WQS for streams. As a result, consideration was given to all biological indicators and stressors identified in previous biological assessments of the Wissahickon Creek basin. The link between nutrient concentrations, DO concentrations, and biological activity in the streams was determined a necessary component of endpoint determination for nutrients. Of the components of instream biological activity, only DO concentrations are included in water quality standards for stream segments of the Wissahickon Creek basin. As a result, the nutrient TMDL endpoint is based on both the minimum and minimum daily average DO for the critical period associated with trout stocking. For siltation impaired stream segments, TMDLs have been established based on target load endpoints estimated from a reference unimpaired watershed.

As part of the nutrient TMDLs, EPA has allocated specific amounts of NH3-N, NO3+NO2-N, orho PO4, and CBOD to certain point and nonpoint sources necessary to restore and maintain applicable WQS for DO. These TMDLs recommend that five facilities have their National Pollution Discharge Elimination System (NPDES) permits modified when next reissued to reduce the amounts of pollutants that may be discharged. The nutrient TMDL and WLAs reported herein are contingent on the assumption that NPDES permits for Ambler Borough (PA0026603), Abington Township (PA0026867), Borough of North Wales (PA0022586), Upper Gwynedd Township (PA0023256), and the Township of Upper Dublin (PA0029441) are amended to increase the effluent DO concentrations to 7.0 mg/L.

TMDLs were determined for each of the two seasonal DO criteria: Trout Stocking (February 15 to July 31) and Warm Water Fishes (remainder of year). For each DO criteria and impaired stream segment of Wissahickon Creek, waste load allocations (WLAs) were specified for all point sources and load allocations (LAs) were specified for all nonpoint sources as part of the TMDLs. The following tables summarize the total WLAs and LAs to address nutrient impairments for each stream segment of the Wissahickon Creek basin included in the State's 303(d) list.

TMDL summary by stream segment for the Wissahickon Creek basin - Trout Stocking (February 15 to July 31)

Sum of Waste Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	258.753	38.509	1058.378	97.398
Wissahickon Creek	971209-1430-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-0930-ACE	1.034	0.202	0.321	0.046
Wissahickon Creek	971222-0930-ACE	543.402	81.466	1657.755	254.221
Wissahickon Creek	971222-1130-ACE	0.000	0.000	0.000	0.000
Lorraine Run	971215-1000-ACE	0.118	0.022	0.052	0.006
Sandy Run	971215-1133-ACE	244.684	23.571	986.281	60.511
Pine Run	971215-1300-ACE	0.000	0.000	0.000	0.000
Pine Run	971215-1303-ACE	120.803	10.747	335.664	14.963
Trewellyn Creek	971217-1145-ACE	0.000	0.000	0.000	0.000

Sum of Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-1430-ACE	835.590	93.169	4064.599	404.039
Wissahickon Creek	971209-0930-ACE	1062.281	122.283	4120.542	415.253
Wissahickon Creek	971222-0930-ACE	159.364	20.025	1033.639	90.568
Wissahickon Creek	971222-1130-ACE	222.733	33.223	1050.113	95.465
Lorraine Run	971215-1000-ACE	123.732	1.344	134.480	1.949
Sandy Run	971215-1133-ACE	114.575	9.822	336.806	14.787
Pine Run	971215-1300-ACE	1.181	0.040	0.986	0.100
Pine Run	971215-1303-ACE	1.181	0.040	0.986	0.100
Trewellyn Creek	971217-1145-ACE	1.922	0.049	0.162	0.029

TMDL summary by stream segment for the Wissahickon Creek basin - Warm Water Fishes (August 1 to February 14)

Sum of Waste Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	445.052	86.405	1051.573	170.411
Wissahickon Creek	971209-1430-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-0930-ACE	1.034	0.202	0.321	0.046
Wissahickon Creek	971222-0930-ACE	543.402	81.466	1646.820	254.221
Wissahickon Creek	971222-1130-ACE	0.000	0.000	0.000	0.000
Lorraine Run	971215-1000-ACE	0.118	0.022	0.052	0.006
Sandy Run	971215-1133-ACE	326.145	65.235	986.281	150.935
Pine Run	971215-1300-ACE	0.000	0.000	0.000	0.000
Pine Run	971215-1303-ACE	137.319	22.868	300.307	21.062
Trewellyn Creek	971217-1145-ACE	0.000	0.000	0.000	0.000

Sum of Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-1430-ACE	973.035	167.356	4031.623	559.839
Wissahickon Creek	971209-0930-ACE	1239.972	206.190	4080.025	575.352
Wissahickon Creek	971222-0930-ACE	278.761	58.710	1032.974	159.435
Wissahickon Creek	971222-1130-ACE	383.300	77.696	1045.820	167.137
Lorraine Run	971215-1000-ACE	123.732	1.344	134.480	1.949
Sandy Run	971215-1133-ACE	130.034	21.600	301.853	20.805
Pine Run	971215-1300-ACE	1.181	0.040	0.986	0.100
Pine Run	971215-1303-ACE	1.181	0.040	0.986	0.100
Trewellyn Creek	971217-1145-ACE	1.922	0.049	0.162	0.029

To estimate siltation endpoints using the reference watershed approach, the Wissahickon Creek and reference watersheds were matched, and a watershed model was used to simulate the sediment loads from different sources. The sediment loads calculated for the reference watersheds were used as endpoints for the impaired watersheds. TMDLs were then developed for the impaired watersheds based on the endpoints. Summaries of the siltation TMDLs, WLAs, and LAs are provided in the following tables for each of the five modeled subwatersheds and stream segments of the Wissahickon Creek basin included on the 303(d) list as impaired. WLAs were provided for all point sources in the basin, including all MS4 stormwater permits for each municipality. For each MS4, WLAs were assigned to all contributions of siltation from both overland runoff and streambank erosion. .

Note that in the tables, the WLA is presented in two different ways. In order to meet the reference watershed sediment loads that were determined to be the TMDL endpoints for each of the five modeled subwatersheds, the loads from NPDES dischargers were multiplied by the SDR in each of the respective watersheds. This resulted in accounting for transport losses of the sediment from the dischargers as it travels through the watershed. The WLA (SDR applied) represents the sediment load from dischargers at the mouth of the watershed after the SDR has been applied. The WLA (SDR not applied) represents the sediment load at the "end of pipe" for each of the dischargers and was based on the permitted flow and TSS concentrations (which were converted to lbs/yr).

TMDLs for impaired watersheds within subwatershed 1

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971217-1430-ACE North Wales Tributary	0.00	314,395.17	314,395.17	37,008.28	351,403.45
971218-1045-ACE Wissahickon Creek	0.00	541,006.02	541,006.02	65,618.03	606,624.04
971218-1345-ACE Wissahickon Creek	0.00	1,143,328.37	653,603.61	63,680.25	717,283.86
981015-1100-ACE Tributary Upstream of North Wales Tributary	0.00	232,545.90	232,545.90	27,199.07	259,744.97
TOTAL	**0.00**	**2,231,275.46**	**1,741,550.69**	**193,505.63**	**1,935,056.33**

*See explanation in above paragraph

TMDLs for impaired watersheds within subwatershed 2

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971216-1415-ACE Rose Valley Tributary	0.00	2,129,859.87	1,624,973.22	180,826.73	1,805,799.95
971217-1015-ACE Willow-Run East	0.00	999,101.77	999,101.77	114,987.28	1,114,089.06
971217-1145-ACE Trewellyn Creek	0.00	1,254,520.88	1,254,520.88	148,082.99	1,402,603.87
971222-0930-ACE Wissahickon Creek	0.00	1,471,917.14	1,471,917.14	170,572.56	1,642,489.70
971222-1130-ACE Wissahickon Creek	0.00	1,052,045.58	1,052,045.58	126,274.19	1,178,319.77
Upstream Load**	290,258.45	0.00	0.00	2,902.58	293,161.03
TOTAL	**290,258.45**	**6,907,445.25**	**6,402,558.59**	**743,646.34**	**7,436,463.38**

*See explanation in above paragraph

**Upstream load includes the TMDL load from subwatershed 1

TMDLs for impaired watersheds within subwatershed 3

Subwatershed	LA	WLA (SDR not applied)	WLA (SDR applied)	MOS	TMDL
971215-1133-ACE Sandy Run	0.00	2,200,406.01	1,903,213.83	210,322.46	2,113,536.29
971215-1300-ACE Pine Run	0.00	1,056,328.02	1,056,328.02	119,072.41	1,175,400.43
971215-1303-ACE Pine Run	0.00	817,420.56	733,988.61	80,997.40	814,986.01
TOTAL	**0.00**	**4,074,154.58**	**3,693,530.45**	**410,392.27**	**4,103,922.72**

*See explanation in above paragraph

TMDLs for impaired watersheds within subwatershed 4

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971208-1000-ACE Wises Mill Tributary	0.00	134,634.68	134,634.68	16,197.25	150,831.92
971209-0930-ACE Wissahickon Creek	0.00	1,603,902.60	1,602,534.82	191,195.19	1,793,730.01
971211-1300-ACE Paper Mill Run	0.00	599,040.65	599,040.65	73,990.17	673,030.82
971215-1000-ACE Lorraine Run	0.00	1,330,422.12	622,454.00	59,816.67	682,270.66
971215-1130-ACE Tributary Downstream of Sandy Run	0.00	784,241.10	784,241.10	96,477.59	880,718.70
Upstream Load**	1,961,865.64	0.00	0.00	196,186.56	2,158,052.20
TOTAL	**1,961,865.64**	**4,452,241.14**	**3,742,905.24**	**633,863.43**	**6,338,634.32**

*See explanation in above paragraph
**Upstream load includes the TMDL load from subwatersheds 2 and 3

TMDLs for impaired watersheds within subwatershed 5

Subwatershed	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971208-1235-ACE Valley Road Tributary	0.00	230,185.11	25,338.69	255,523.81
971208-1430-ACE Monoshone Creek	0.00	519,867.90	59,260.72	579,128.61
971209-1200-ACE Creshiem Creek	0.00	885,240.83	101,969.27	987,210.10
971209-1430-ACE Wissahickon Creek	0.00	1,133,903.32	133,402.74	1,267,306.06
971208-1000-ACE Wises Mill Tributary	0.00	357,050.74	40,418.87	397,469.61
Upstream Load*	1,172,647.35	0.00	117,264.74	1,289,912.09
TOTAL	**1,172,647.35**	**3,126,247.90**	**477,655.03**	**4,776,550.28**

*Upstream load includes the TMDL load from subwatershed 4

1.0 Introduction

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting their designated uses even though pollutant sources have implemented technology-based controls. A TMDL establishes the allowable load of a pollutant or other quantifiable parameter based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of the state's water resources (USEPA, 1991).

As a result of biological investigations conducted by the Pennsylvania Department of Environmental Protection (PA DEP) that identified observed impacts on aquatic life, much of the Wissahickon Creek watershed has been listed on the State's 303(d) list of impaired waters. The watershed is heavily impacted by urbanization and is listed as impaired due to problems associated with elevated nutrient levels, low dissolved oxygen concentrations, siltation, chlorine, water/flow variability, oil and grease, and pathogens. This study will fulfill the requirements for nutrient and siltation TMDL development for all waters in the Wissahickon Creek basin included in the State's 303(d) list. Separate studies are underway to address those impairments resulting from chlorine, oil and grease, pathogens, and low dissolved oxygen concentrations. These studies will address the impairments through either direct TMDL development or additional monitoring to determine if recent changes in management practices have resulted in improved water quality conditions and subsequent removal of the stream segments from the 303(d) list. For those stream segments listed as impaired as a result of "water/flow variability" and "other habitat alterations," sources of impairments are related to those sources contributing to the nutrient and siltation impairments. Therefore, through implementation of best management practices to address nutrient and siltation TMDLs, these related impairments will be addressed indirectly.

1.1 Background Information

The Wissahickon Creek drains approximately 64 square miles and extends 24.1 miles in a southeasterly direction through lower Montgomery and northwestern Philadelphia Counties (Figure 1.1). Major tributaries in the basin include Sandy Run and Pine Run, draining a heavily urbanized area east of the mid-section of the watershed. Other tributaries to Wissahickon Creek include Trewellyn Creek, Willow Run - East, Willow Run - West, Rose Valley Tributary, Paper Mill Run, Creshiem Creek, Monoshone Creek, Prophecy Creek, Lorraine Run, Wises Mill Tributary, and Valley Road Tributary. All tributaries mentioned are included with the mainstem of the Wissahickon Creek on Pennsylvania's 303(d) list of impaired waters.

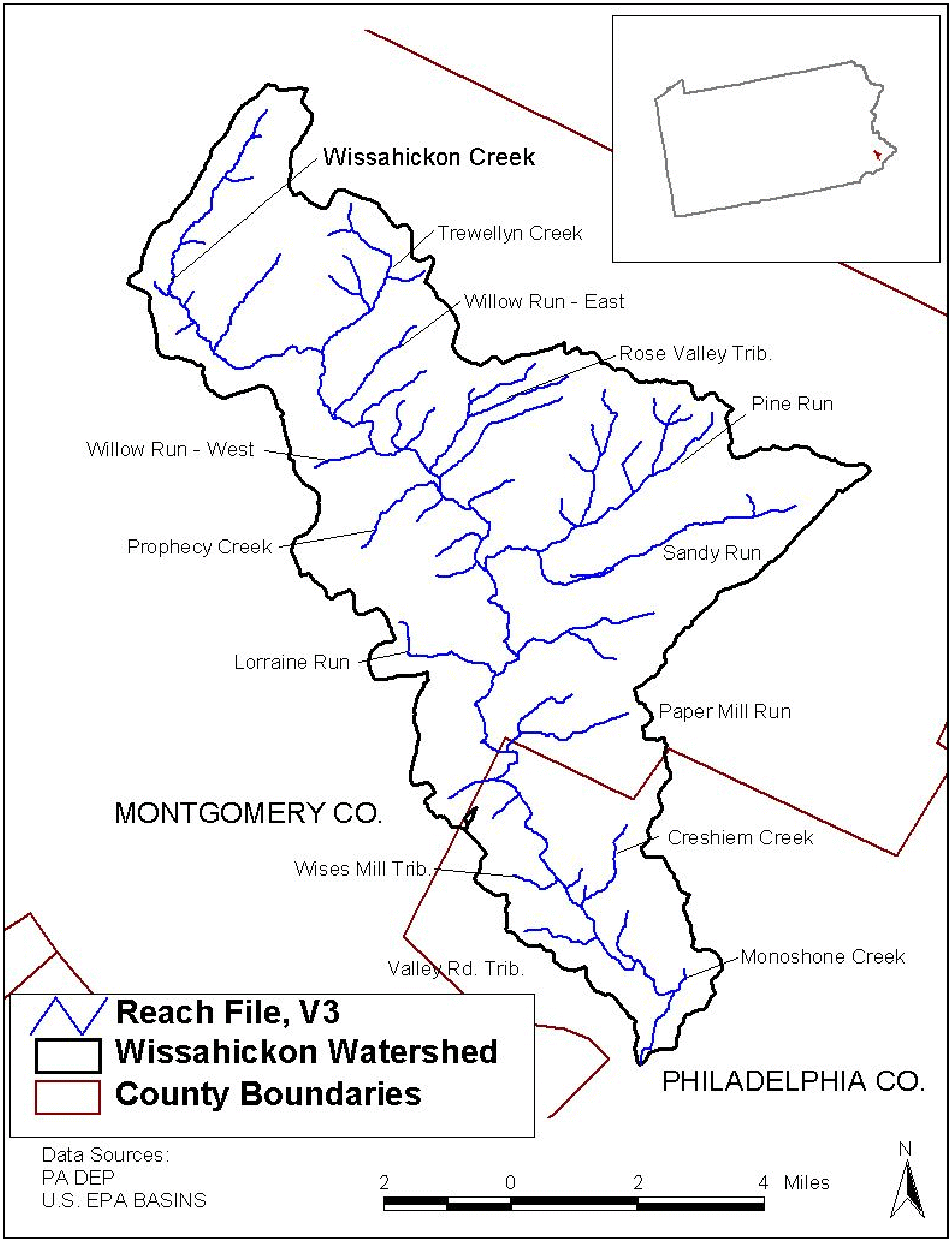

Figure 1-1. Wissahickon Creek watershed

The headwaters and upper portions of the watershed consist primarily of residential, agricultural, and wooded land use. The mid-section of the watershed is dominated by industrial, commercial, and residential land use. The lower 6.8 miles of the watershed is enclosed by Fairmount Park, which is maintained for recreational use. Tributaries of the lower portion of the watershed provide storm drainage from single and multi-family residential areas.

Biological investigations of Wissahickon Creek over the past 20 years have repeatedly documented a problem regarding eutrophic conditions in the mainstem and tributaries (Boyer, 1975; Strekal, 1976; Boyer, 1989; Schubert, 1996; Boyer, 1997; Everett, 2002). Total phosphorus concentrations decreased substantially in 1988 as a result of a combination of the phosphate ban and wastewater treatment plant upgrades and/or phasing out of smaller treatment plants. However, levels are still significant enough to result in nuisance algal growth (Boyer, 1997). Results of a 1998 survey of the periphyton conducted by PA DEP indicate that excess nutrient levels in the Wissahickon Creek may be contributing to impairments found in the watershed by causing an alteration in the benthic community as a result of increasing algal biomass (Everett, 2002). Analysis of the periphyton data by the Academy of Natural Sciences of Philadelphia (ANSP) concluded that the Wissahickon Creek is a nutrient enriched system, with eutrophic conditions present in the stream as a whole. ANSP further concluded that this eutrophication can be attributed to sewage treatment plant (STP) effluents and possibly leached fertilizers and other runoff (West, 2000; Everett, 2002). As further evidence of eutrophic conditions, diurnal dissolved oxygen sampling performed by PA DEP in 1999 and 2002 showed repeated violations of State water quality criteria.

Another impact on the biological community and a source of impairment is the diminution of baseflow. Several portions of the headwaters and tributaries have exhibited no baseflow during PA DEP 1997 inspections conducted in conjunction with the Unassessed Waters Program, an August 2001 site visit conducted by PA DEP and EPA Region 3, and PA DEP data collection of Summer 2002. Sources of baseflow reduction may be a result of one or more of several activities, including the increase of impervious area and subsequent loss of groundwater recharge resulting from urbanization, and groundwater pumping and drawdown (personal communication with Alan Everett, PA DEP). Diminution of baseflow is addressed directly as an impairment included in the 303(d) list under the category of Water/Flow Variability. Management practices suggested in Section 5 to address nutrient and siltation impairments also address impairments due to Water/Flow Variability.

Habitat alteration is affected not only by increased biomass and diminution of baseflow, but also hydraulic/hydrology changes resulting from increased urbanization. Generally, there are three major forms of habitat modification related to hydrologic/hydraulic enhancements caused by urbanization: (1) instream modifications produced by increased stormflows (siltation, bank destabilization, embeddedness, etc.), (2) out-of-stream habitat alterations (riparian vegetation removal, bank alteration, etc.), and (3) stream encroachments (dams, enclosures, bridges, etc.) (personal communication with Alan Everett, PA DEP). All three categories of habitat modification are interrelated and are addressed directly as a source of impairment for segments included in the 303(d) list for Habitat Alterations. Siltation and Water/Flow Variability are also addressed separately in the 303(d) list, but are related to Habitat Alterations. Through the use of management practices suggested in Section 5 to address nutrient and siltation impairments, Habitat Alterations are also addressed since the impairments are related and of the same source.

1.2 Impairment Listing

TMDL development for this study was limited to nutrient and siltation impairments. A complete list of all impaired segments in the Wissahickon Creek basin is provided in Appendix A.

1.2.1 Nutrient Impairments

Ten stream segments in the Wissahickon Creek watershed have been included in Pennsylvania's 303(d) list due to nutrient impairments (Table 1-1; Figure 1-2). These include five segments of the Wissahickon Creek mainstem as well as five stream segments of tributaries. Sources of nutrients have been identified as municipal point sources and urban runoff/storm sewers.

Table 1-1. Nutrient impaired stream segments of the Wissahickon Creek basin

Segment Name	Segment ID	Pollutant	Source	Year Listed
Wissahickon Creek	971218-1345-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971209-1430-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971209-0930-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971222-0930-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971222-1130-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Lorraine Run	971215-1000-ACE	Nutrients	Urban Runoff/Storm Sewers	1998
Sandy Run	971215-1133-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998
Pine Run	971215-1300-ACE	Nutrients	Urban Runoff/Storm Sewers	1998
Pine Run	971215-1303-ACE	Nutrients	Municipal Point Source; Urban Runoff/Storm Sewers	1998

Segment Name	Segment ID	Pollutant	Source	Year Listed
Trewellyn Creek	971217-1145-ACE	Nutrients	Urban Runoff/Storm Sewers	1998

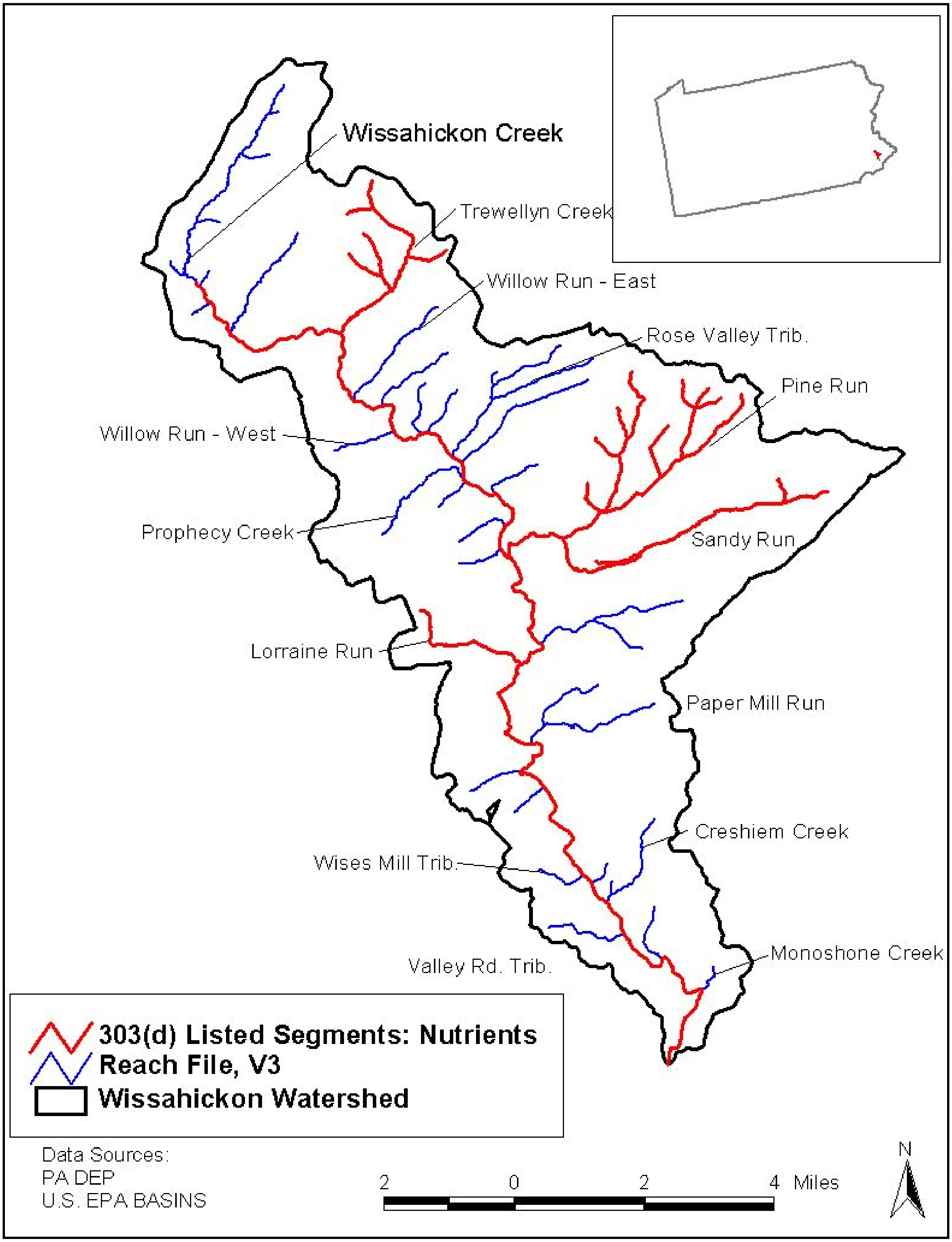

Figure 1-2. Wissahickon Creek segments impaired due to nutrients

1.2.2 Siltation Impairments

Twenty one stream segments in the Wissahickon Creek watershed have been included on Pennsylvania's 303(d) list due to siltation impairments (Table 1-2; Figure 1-3). These include the six segments of Wissahickon Creek as well as fifteen additional stream segments in the watershed. Sources of siltation impairments include urban runoff/storm sewers and habitat modification.

Table 1-2. Siltation impaired stream segments of the Wissahickon Creek basin

Segment Name	Segment ID	Pollutant	Source	Year Listed
Wissahickon Creek	971209-0930-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971209-1430-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971218-1045-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971218-1345-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971222-0930-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wissahickon Creek	971222-1130-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Monoshone Creek	971208-1430-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Creshiem Creek	971209-1200-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Valley Road Tributary	971208-1235-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Wises Mill Tributary	971208-1000-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Paper Mill Run	971211-1300-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Lorraine Run	971215-1000-ACE	Siltation	Surface Mining	1998
Tributary Downstream of Sandy Run	971215-1130-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Sandy Run	971215-1133-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Pine Run	971215-1303-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Pine Run	971215-1300-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Rose Valley Tributary/Tributary Downstream of Rose Valley Tributary	971216-1415-ACE	Siltation	Urban Runoff/Storm Sewers	1998

Segment Name	Segment ID	Pollutant	Source	Year Listed
Willow Run - East/Tributary Downstream of Willow Run - East	971217-1015-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Trewellyn Creek	971217-1145-ACE	Siltation	Urban Runoff/Storm Sewers	1998
North Wales Tributary/Tributary Upstream of North Wales Tributary	971217-1430-ACE	Siltation	Urban Runoff/Storm Sewers	1998
Tributary Upstream of North Wales Tributary	981015-1100-ACE	Siltation	Habitat Modification	1998

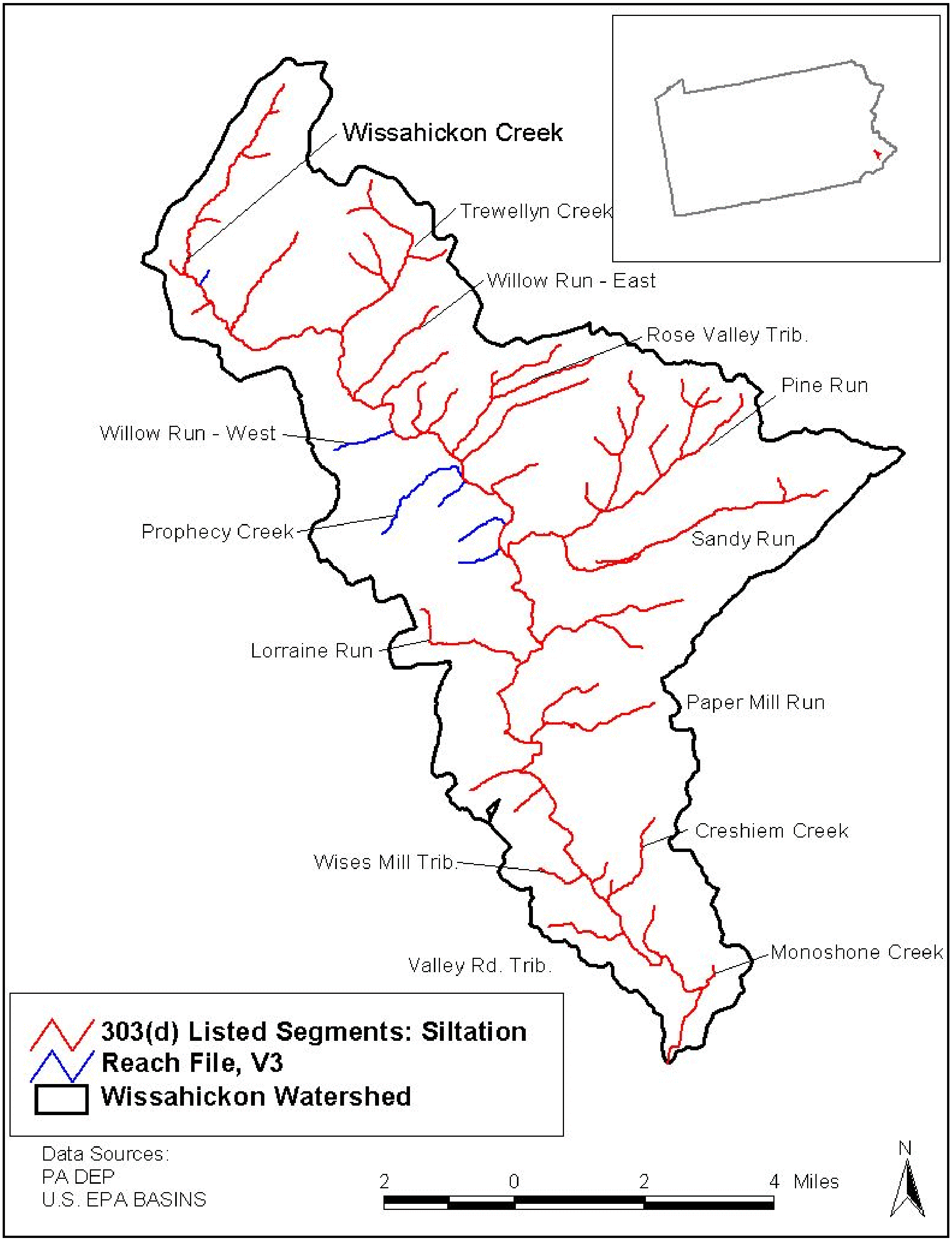

Figure 1-3. Wissahickon Creek segments impaired due to siltation

1.3 Water Quality Standards

Pennsylvania Code, Title 25, Chapter 93 sets forth water quality standards for surface waters of the state. These standards are based upon water uses which are to be protected and will be considered by PA DEP in its regulation of discharges. Wissahickon Creek is designated for trout stocking, and is subject to all water quality criteria specific to this designated use and those defined for general statewide water uses. Trout stocking is defined as “maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat” (PA Code, Title 25, 93.3). Statewide water uses include aquatic life, water supply, and recreation. For all designated water uses of Wissahickon Creek, the numeric water quality in Table 1-3 are applicable.

Implementation of the numeric water quality criteria summarized in Table 1-3 is outlined in PA Code, Title 25, Chapter 96.3 as follows:

Chapter 96.3(c): “ To protect existing and designated surface water uses, the water quality criteria described in Chapter 93 (relating to water quality standards), including the criteria in Chapters 93.7 and 93.8a(b) (relating to specific water quality criteria; and toxic substances) shall be achieved in all surface waters at least 99% of the time, unless otherwise specified in this title. The general water quality criteria in Chapter 93.6 (relating to general water quality criteria) shall be achieved in surface waters at all times at design conditions.”

Chapter 96.3(d): “As an exception to subsection (c), the water quality criteria for total dissolved solids, nitrite-nitrate nitrogen, phenolics and fluoride established for the protection of potable water supply shall be met at least 99% of the time at the point of all existing or planned surface potable water supply withdrawals unless otherwise specified in this title.”

In addition to numeric water quality criteria, Wissahickon Creek is also subject to narrative criteria stated in PA Code, Title 25, Chapter 93.6 as follows:

Chapter 93.6(a): “Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.”

Chapter 93.6(b): “In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, odors, turbidity or settle to form deposits.”

Table 1-3. Numeric water quality standards (PA Code, Title 25, Chapter 93.7)

Pollutant	Designated Use	Criteria		Period
		Minimum Daily Average	Minimum	
Dissolved Oxygen (mg/L)	Trout Stocking (specific)	6.0	5.0	Feb. 15 to July 31
	Warm Water Fishes (statewide)	5.0	4.0	remainder of year
		Maximum		
Nitrite plus Nitrate as Nitrogen (mg/L)	Potable Water Supply (statewide)	10.0		year round
Fecal Coliform (#/100 mL)	Water Contact Sports (statewide)	Maximum geometric mean of 200 per 100 mL, based on a minimum of 5 consecutive samples each sample collected on different days during a 30-day period.	No more than 10% of the total samples taken during a 30-day period may exceed 400 per 100 mL	May 1 to Sept. 30
		Maximum geometric mean of 2,000 per 100 mL, based on a minimum of 5 consecutive samples each sample collected on different days during a 30-day period		remainder of year
	Potable Water Supply (statewide)	Maximum of 5,000 coliforms per 100 mL as a monthly average value, no more than this number in more than 20 samples collected during a month, nor more than 20,000 per 100 mL in more than 5% of the samples		year round
Chloride (mg/L)	Potable Water Supply (statewide)	max = 250		year round
Sulfates (mg/L) *	Potable Water Supply (statewide)	max = 250		year round
TDS (mg/L)	Potable Water Supply (statewide)	max = 750	mo. avg. = 500	year round
TRC (mg/l)	Warm Water Fishes (statewide)	4-day avg. = 0.011	1-hr avg. =0.019	year round
Ammonia Nitrogen	Aquatic life (statewide)	pH and temp. dependent	pH and temp. dependent	year round

* The PA Environmental Quality Board recently proposed to move the point of application of the criteria for sulfate and chloride to the point of all existing or planned surface potable water supply withdrawals.

2.0 Source Assessment

Analyses were performed on historical water quality and streamflow data to determine critical flow conditions and relative loads to assess the impact of point and nonpoint sources on instream water quality. These analyses helped to assess nutrient and siltation sources in the Wissahickon Creek watershed. Identification of critical flow conditions was an important step in determining the methodology used for TMDL development. Under these conditions, the relative impacts of nutrients and siltation sources differed.

2.1 Nutrient Sources

Review of historical data collected at the mouth of Wissahickon Creek provided much insight into the critical period for impact analysis. Once this condition was identified, focus could be directed to those sources that have the most impact during such periods.

2.1.1 Identification of Critical Period (Low-Flow)

Nutrient data has been collected by various agencies at multiple locations on Wissahickon Creek and its tributaries. However, the only historical record of nutrients that extends to present is at the mouth of Wissahickon Creek. From an analysis of streamflow data from USGS gage 01474000 combined with streamflow and water quality data from PA DEP gage WQN0115, relationships between the magnitude of streamflow and levels of nutrients were established. To ensure that the analysis provides an accurate description of current conditions, data was limited to the period of record from 1990 to 2001. Figures B-1 through B-4 of Appendix B depict statistical and graphical results from the analyses and show that levels of nitrate and phosphorus are higher during periods of low streamflow. This correlation suggests that the critical condition is during low-flow, when nutrient contributions are dominated by point sources or other direct discharges. In addition, nutrient concentrations are shown to vary seasonally, with higher nutrient concentrations generally occurring in the summer and fall.

2.1.2 Point Sources of Nutrients

During low-flow periods, Wissahickon Creek nutrient concentrations are dominated by point source contributions. This was shown in the analyses of 1998 data reported in *Data Review for Wissahickon Creek, Pennsylvania* (Tetra Tech, Inc., 2002), and was validated with additional data collected in 2002 by PA DEP during low-flow conditions of summer 2002. Results of the summer 2002 data collection are summarized in Figures C-1 through C-6 of Appendix C. For both periods, major point sources are observed to have noticeable impacts on nutrient concentrations in the streams.

National Pollutant Discharge Elimination System (NPDES) permitted dischargers in the Wissahickon Creek watershed are summarized in Table 2-1. The discharges range from single family discharges (about 400 to 700 gallons per day) to large industrial and municipal wastewater treatment plants with effluent rates in the range of 1 to 7 million gallons per day (MGD). Major dischargers are defined as those with substantial permitted flows constituting the majority of streamflow in the Wissahickon Creek basin during low-flow periods. Major NPDES facilities in the Wissahickon Creek basin include Ambler Borough (6.5 MGD), Upper Gwynedd Township (5.7 MGD), Abington Township (3.91 MGD), Upper Dublin Township (1.1 MGD), and North Wales Borough (0.835 MGD). Locations of all major and minor discharges are depicted in Figure 2-1.

Table 2-1. Point sources of nutrients in the Wissahickon Creek basin

NPDES No.	Receiving Waterbody	Flow (MGD)	Facility Name	Industry Classification
PA0012190	Wissahickon Creek	0.01775	Precision Tube Co – Mueller St	Roll, Draw & Extrud Nonferrous
PA0023256	Wissahickon Creek	5.7[a]	Upper Gwynedd Township	Sewerage Systems
PA0026603	Wissahickon Creek	6.5	Ambler Boro	Sewerage Systems
PA0052515	Wissahickon Creek	0.0168	Ambler Borough Water Department	Filter Backwash From STP
PA0053538	Wissahickon Creek	na	Merck & Company, Inc	Pharmaceutical Preparations
PA0055387[d]	Wissahickon Creek	0.001	PA Historical & Museum Commission	Sewerage Systems
PA0022586	Tributary to Wissahickon Creek	0.835	North Wales Boro	Sewerage Systems
PA0054577	Tributary to Wissahickon Creek	0.0007[c]	Fishbone, David	Sewerage Systems
PA0057177[d]	Tributary to Wissahickon Creek	0.0004	Plummer, J. Randall	Sewerage Systems
PA0057576	Tributary to Wissahickon Creek	0.0007	Bruce K. Entwisle	Sewerage Systems
PA0053074	Sandy Run	0.0083	Valley Green Corporate Center	Oper of Nonresidential buildings
PA0056901	Sandy Run	0.0136	Jiffy Lube International, Inc	Auto Serv, Exc Rep & Carwashes
PA0026867	Sandy Run	3.91	Abington Township	Sewerage Systems
PA0050865	Rose Valley Tributary	0.053	Gessner Products Co Inc	Plastics Products, NEC
PA0029441	Pine Run	1.1[b]	Upper Dublin Township	Sewerage Systems
PA0013048	Pine Run	na	Honeywell, Inc.	Industrial instruments
PA0051012	Lorraine Run	0.0004	Harris, Albert & Cynthia	Oper of dwelling other than apartment
PA0057631	Lorraine Run	0.0005	Sayers, David & Marie	Sewerage Systems
PA0053210	Lorraine Run	0.0005	Murray SRSTP	Sewerage Systems

a - Approval granted 3/12/20028 for plant expansion from 4.5 to 5.7 MGD
b - Approval granted 9/18/1998 for plant expansion from 1.0 to 1.1 MGD
c - Permit expired; renewal expected.
d - Permit expired; renewal questionable
na - not applicable; monitoring only

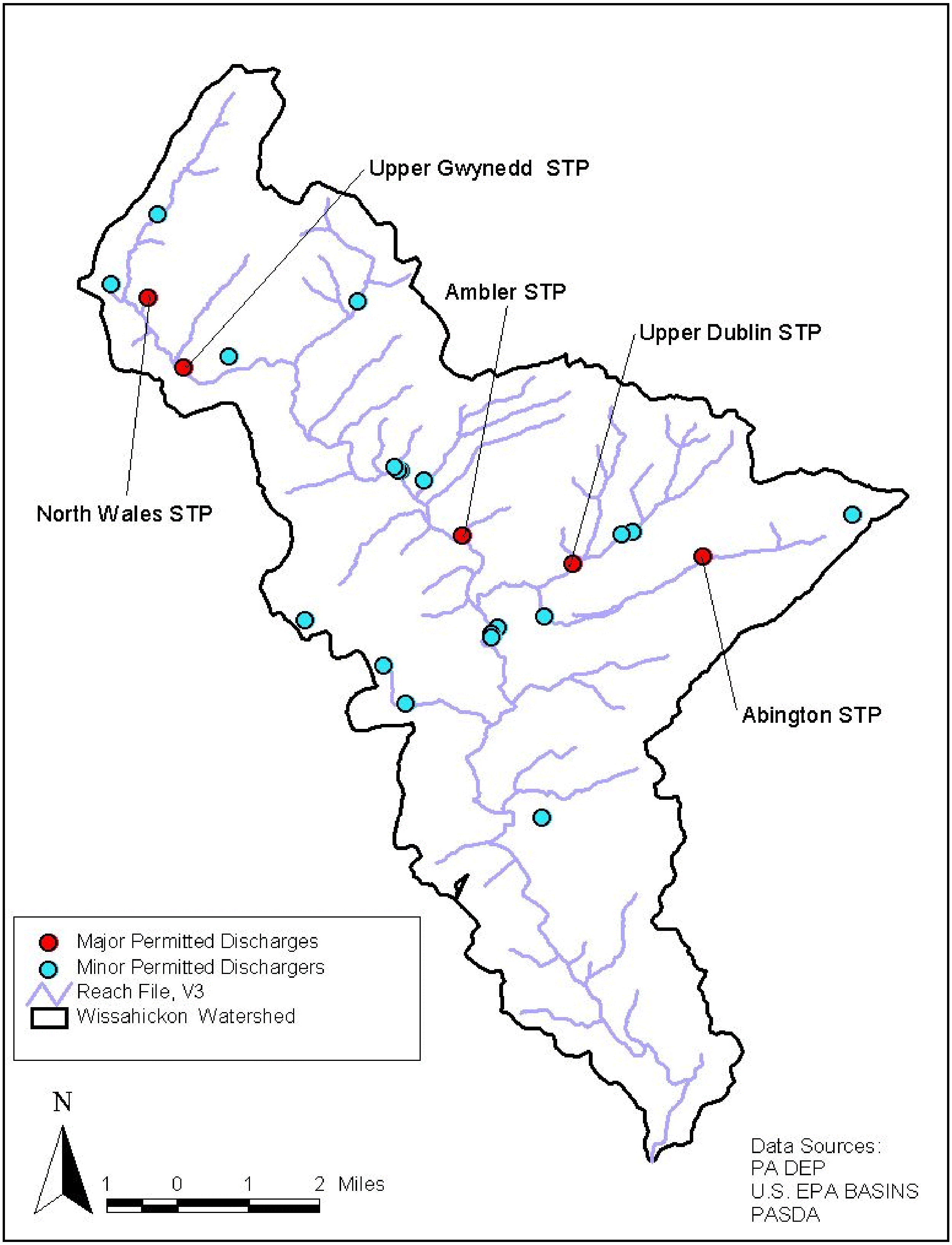

Figure 2-1. Locations of NPDES dischargers in the Wissahickon Creek basin

2.1.3 Nonpoint Sources of Nutrients

During the critical low-flow period, impacts from nonpoint sources are limited since storm runoff is not a factor during such dry conditions. However, other nonpoint sources can potentially impact the streams under such conditions, including runoff from irrigated golf courses, areas with high concentration of septics and/or history of failure, unimpeded cattle access to streams, and impacts of low level dams.

2.1.3.a Golf Courses

During the summer 2002 instream monitoring study performed by PA DEP during low-flow critical conditions, water quality samples were taken upstream and downstream of two golf courses on Sandy Run selected to represent impacts of golf courses on streams of the Wissahickon Creek basin. If substantial impacts were observed, more robust monitoring would be performed to better characterize loads from these areas. However, during the monitoring period, no outstanding increases in nutrient concentrations were observed in the vicinity of the golf courses (Figures C-4 and C-5 of Appendix C). Although increases in diurnal variability of DO in these areas (Figure C-6) suggests an increase in biological activity, this occurrence is likely the result of reduced shading from tree canopy and nutrient loads from upstream sources.

2.1.3.b Septic Systems

PA DEP determined that during low-flow conditions, impacts from failed septic systems are negligible since most of the watershed utilizes sanitary sewer services.

2.1.3.c Unimpeded Cattle Access to Streams

Unimpeded cattle access is limited to one farm, but this area only impacts the lower portion of the watershed where water quality is less problematic. Moreover, without sufficient supporting data, it is difficult to make assumptions for loads from such sources. However, it was found that by reducing loads in the upstream portions of the watershed to improve conditions in the stream segments where the sources originate, the water quality improved to the point that no local reductions were required for the bottom portion of the Wissahickon Creek watershed (below Route 73). In any case, restoration projects are currently proposed by PA DEP for this portion of the watershed that will seek to reduce these impacts.

2.1.3.d Low Level Dams

Low level dams located throughout the watershed provide opportunity for instream sources of nutrients through sediment release from pooled areas. To assess the impacts from these dams, PA DEP monitored water quality upstream and downstream of two dams on Wissahickon Creek (Figures C-1 through C-3 of Appendix C). If impacts proved significant, a more robust assessment of nutrient loads from the dams would be considered. However, except for a small increase in total phosphorus at one of the dams (Gross Dam), impacts were determined minimal. Rather than attribute a source of nutrients to dams, the effects were accounted for in the water quality calibration of the model.

2.1.4.e Coorson's Quarry

Coorson's Quarry discharges an average of 12.5 cfs to Lorraine Run. This flow is a significant contributor to Wissahickon Creek baseflow and provides reductions to Wissahickon Creek nutrient concentrations through dilution. To assess the benefits of the quarry discharge, a sensitivity analysis was performed using the low-flow model. Results of analysis are reported in the *Modeling Report for Wissahickon Creek, Pennsylvania Nutrient TMDL Development - Draft* (hereafter referred to as Modeling Report) and showed that if quarry discharges are discontinued, additional DO problems will likely result in the bottom portions of Wissahickon Creek below Lorraine Run. Also, due to the substantial reduction of streamflow that would occur in Lorraine Run, aquatic life within the stream would be affected beyond problems associated with low DO. Therefore, the discharge from Coorson's Quarry benefits the Wissahickon Creek and Lorraine Run, and continued operation of the quarry should be encouraged.

2.1.4.f Background

Although low-flow conditions are dominated by point source contributions, a small amount of baseflow is present with background nutrient concentrations likely controlled by groundwater. These background contributions are extremely small in comparison to point source contributions during low-flow conditions. As a result, background nutrient loads are accounted for in analyses, but impacts are negligible.

2.2 Siltation Sources

Review of historical data collected at the mouth of Wissahickon Creek provided much insight into the critical period for impact analysis. Once this condition was identified, focus could be directed to those sources that have the most impact during such periods.

2.2.1 Identification of Critical Period (High-Flow)

Sources of siltation are generally associated with nonpoint sources and wet weather streamflows. To test this assumption for Wissahickon Creek, total suspended solids (TSS) levels measured at the mouth from 1990 to 2001 were compared against flows. Results of this analysis are reported in Figures B-5 and B-6 of Appendix B. As can be seen from these results, TSS levels during high flows are almost an order of magnitude greater than levels observed at normal flows. Periods of such high flows and corresponding high TSS concentration suggests a relatively large solids loading and potential for siltation to the Wissahickon Creek streambed during wet periods.

2.2.2 Point Sources of Siltation

During wet weather conditions, the impact of point sources listed in Table 2-1 on the total siltation loads to the streams is negligible. However, for those point sources in the Wissahickon Creek watershed with limits for TSS in NPDES permits, those permit limits were considered in the final waste load allocations.

2.2.2.a Overland Sources

Runoff from urban areas carries significant loads of sediment that deposits in the streambed. EPA's stormwater permitting regulations require municipalities to obtain permit coverage for all storm water discharges from separate storm sewer systems (MS4s). Implementation of these regulations are phased such that large and medium sized municipalities were required to obtain storm water permit coverage in 1990 and small municipalities by March 2003. As such, Philadelphia has an existing MS4 permit and surrounding smaller municipalities in the watershed will have storm water permits by March 2003. Figure 2-2 depicts the municipal boundaries within the Wissahickon Creek basin. For each municipality, the sediment loads from stormwater collection systems are considered as point source contributions, which require specific wasteload allocations for each MS4 permit.

To assess the relative loads of sediment from different land uses within municipal boundaries, it was important to have the most recent and updated land use data available. A current land use dataset for the Wissahickon Creek watershed was developed by the Environmental Resources Research Institute of Penn State University by updating the National Land Cover Data (NLCD) (Vogelmann et al., 1998) using SPOT (System Probatoire pour l'Observation de la Terre) satellite imagery from 2000. The relative areas for each land use in the Wissahickon Creek basin are listed in Table 2-2. The most predominant land uses in the basin are low-intensity residential (38.7%), deciduous forest (26.0%), and a mix between high-density residential and urban (11.5%). Urban and residential land uses in the Wissahickon Creek basin account for over 50% of the total area, and are considered to be major contributors to sediment loads in the Wissahickon Creek watershed.

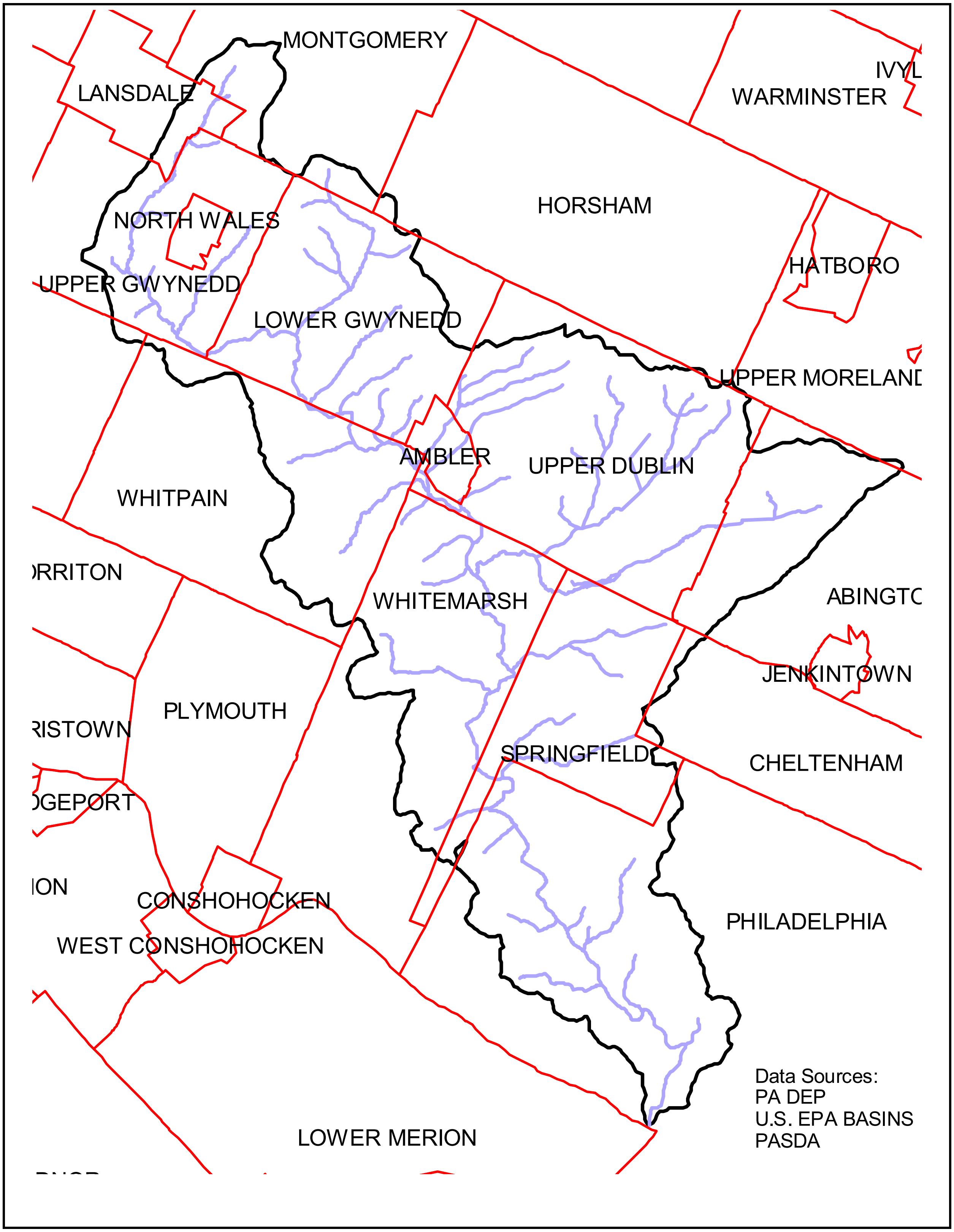

Figure 2-2. Municipal boundaries in the Wisahickon Creek watershed

Table 2-2. Land uses of the Wissahickon Creek watershed

Land Use	Area (sq. mi.)	Percent
Water	0.1	0.2
Low-Intensity Residential	24.7	38.7
High-Intensity Residential/Urban	7.4	11.5
Hay/Pasture	3.8	6.0
Row Crops	3.9	6.0
Coniferous Forest	1.4	2.2
Mixed Forest	5.6	8.7
Deciduous Forest	16.6	26.0
Quarry	0.2	0.2
Coal Mines	0.0	0.0
Transitional	0.2	0.4

2.2.2.b Streambank Erosion

The largest contributor of sediment to Wissahickon Creek are instream sources attributed to streambank erosion. Urbanization and paving of large areas of the watershed result in dramatic increases in stormwater runoff, which lead to periodic high flows that erode stream banks, contributing silt to the shallow creek bottom. These sources are extremely difficult to pinpoint, measure, and control, but they are currently the leading cause of siltation in the Wissahickon Creek basin. Using the modeling tools and approach outlined in Section 4.2 and Appendix E, the sediment load resulting from streambank erosion could be estimated. Since the cause of the flow variability that results in streambank erosion is related to urban runoff, the sources of the impairments are considered point sources under the MS4 stormwater permits.

2.2.3 Nonpoint Sources of Siltation

Because all of the Wissahickon Creek watershed is covered by MS4 stormwater permits, all sources of siltation to Wissahickon Creek and tributaries (i.e., overland flow and streambank erosion) are considered by EPA as point sources (see Section 2.2.2).

3.0 TMDL Endpoint Determination

To meet the designated uses of Wissahickon Creek and its tributaries, water quality targets, or *endpoints*, must be met under the critical conditions outlined in Sections 2.1.1 and 2.2.1. Selection of these endpoints consider the water quality standards prescribed by those designated uses (Section 1.3), but where no guidance is found in the standards, site-specific criteria were determined.

3.1 Nutrient TMDL Endpoint

There are presently no numeric nutrient criteria defined by PA DEP water quality standards for streams. As a result, consideration was given to all biological indicators and stressors identified in previous biological assessments of the Wissahickon Creek basin (see Section 1.1). To provide additional decision support, data collected in 1998 and 2002 were analyzed. Results of analyses of 1998 data collected by PA DEP, the Academy of Natural Sciences of Philadelphia (ANSP), and the National Institute of Environmental Renewal (NIER) were reported in *Data Review of Wissahickon Creek, Pennsylvania* (Tetra Tech, Inc., 2002). Results of analyses of 2002 data collected by PA DEP are summarized in Appendix C. These results clearly show a pronounced diurnal fluctuation of DO at several locations of Wissahickon Creek and its tributaries. At many sampling locations, the seasonal standard for minimum and minimum daily average DO concentrations were not met.

The link between nutrient concentrations, DO concentrations, and biological activity in the streams was determined a necessary component of endpoint determination. This is especially true since biological impacts were a consideration in the original listing of the waterbodies as impaired due to nutrients. Of the components of instream biological activity, only DO concentrations are included in water quality standards as numeric criteria for stream segments of the Wissahickon Creek basin. The standards for DO are based on levels required to support fish populations, with the critical period (period of higher required concentrations) based on trout stocking. This period requires a minimum DO level of 5.0 mg/L and a minimum daily average of 6.0 mg/L to support Trout Stocking (TS) from February 15 through July 31. For the remainder of the year, a minimum DO level of 4.0 mg/L and a minimum daily average of 5.0 mg/L are required to support Warm Water Fish (WWF).

Nutrient TMDL endpoints are based on both the minimum and minimum daily average DO for the critical periods associated with TS and WWF. However, in analyses of the streams ability to meet these standards, it was necessary to consider all biological processes that are factors in the impairment of the waterbodies. These factors included the link between nutrient levels and biological activity, including effects of periphyton/algae growth and the resulting diurnal variability of DO resulting from biological processes.

3.2 Siltation TMDL Endpoint

Because Pennsylvania has no numeric in-stream criteria for the pollutants of concern, a "reference watershed" approach was developed to set allowable loading rates in the impaired watersheds to protect designated uses.

3.2.1 Reference Watershed Approach

The reference watershed approach is used to estimate the necessary load reduction of sediment that would be needed to restore a healthy aquatic community and allow the streams in the watershed to achieve their designated uses. The reference watershed approach is based on determining the current loading rates for the pollutants of interest from a selected unimpaired watershed that has similar physical characteristics (i.e., landuse, soils, size, geology) to those of the impaired watershed.

The reference watershed approach pairs two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land cover and land use characteristics. Other features such as base geologic formation, soils, percent slope, landuse, and ecoregion should be matched to the extent possible (see Appendix E for greater detail). The objective of this process is to reduce the loading rate of sediment in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream segment. Achieving the sediment loadings recommended in the TMDLs will ensure that the designated aquatic life of the impaired stream is achieved.

3.2.2 Considerations for Reference Watershed Selection

Two factors formed the basis for selecting a suitable reference watershed. The first factor was to use a watershed that had been assessed by PA DEP and had been determined to attain water quality standards and meet designated uses. The second factor was to find a watershed that closely resembled the impaired watershed in physical properties such as land cover/land use, physiographic province, size, and geology. This was done by means of a desktop screening using several GIS coverages. The GIS coverages included the USGS named stream watershed coverage, the state water plan boundaries, the satellite image-derived land cover grid (MRLC), streams, and Pennsylvania's 305(b) assessed streams database.

There were four steps in determining the reference watersheds that were used to derive the target limits for the TMDLs. Figure 3-1 shows these four steps and how they are used in deriving the target limits. The first step was to locate watersheds that had been recently assessed and were not impaired. Step 2 was to identify a pool of unimpaired watersheds similar in size and geology to the impaired watersheds. Step 3 involved comparing the land cover data of the watersheds and selecting unimpaired watersheds that had land cover characteristics similar to those of the impaired watersheds. Land use distributions were compared on a percentage basis as calculated

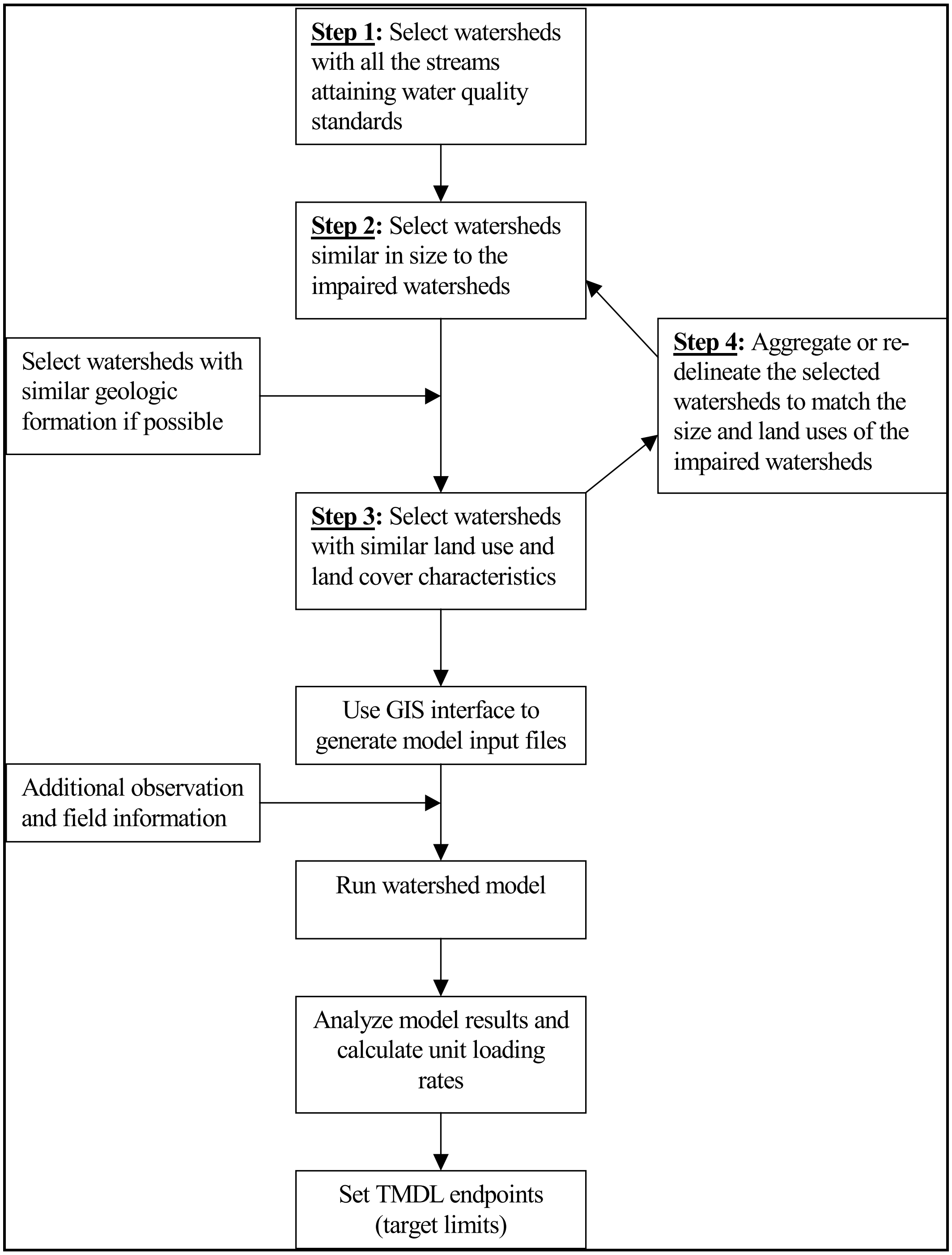

Figure 3-1. Flow chart for the derivation of TMDL target limits. Steps 1 to 4 are used for the determination of the reference watershed.

from MRLC land use data. It was important to have a good match between the sizes of the reference and impaired watersheds so that reasonable comparisons could be made. As a result, the fourth step was used to resize the reference watersheds to produce reasonable matches to the impaired watersheds (see Appendix E).

Once the reference watersheds were selected, their existing sediment loads could be estimated based on watershed modeling using Pennsylvania GIS data. The estimated existing loads were analyzed and then considered as the endpoints or target limits for the impaired streams.

3.2.3 Selected Reference Watershed and Endpoints

The TMDL endpoints established for this study were determined using Ironworks Creek as the reference watershed (Figure 3-2). The methodology used for identification of candidate reference watersheds and final selection of Ironworks Creek as the target is outlined in Appendix E. The listed segments in the Wissahickon Creek watershed were grouped into five subwatersheds within the Wissahickon Creek watershed for the purpose of matching the waterbodies with an appropriate reference watershed (see Appendix E). Table 3-1 presents each of the five subwatersheds and their associated 303(d)-listed waterbody segments along with their corresponding endpoints determined through the reference approach. The TMDL process uses loading rates in the non-impaired watersheds as targets for loading reductions in the impaired watersheds.

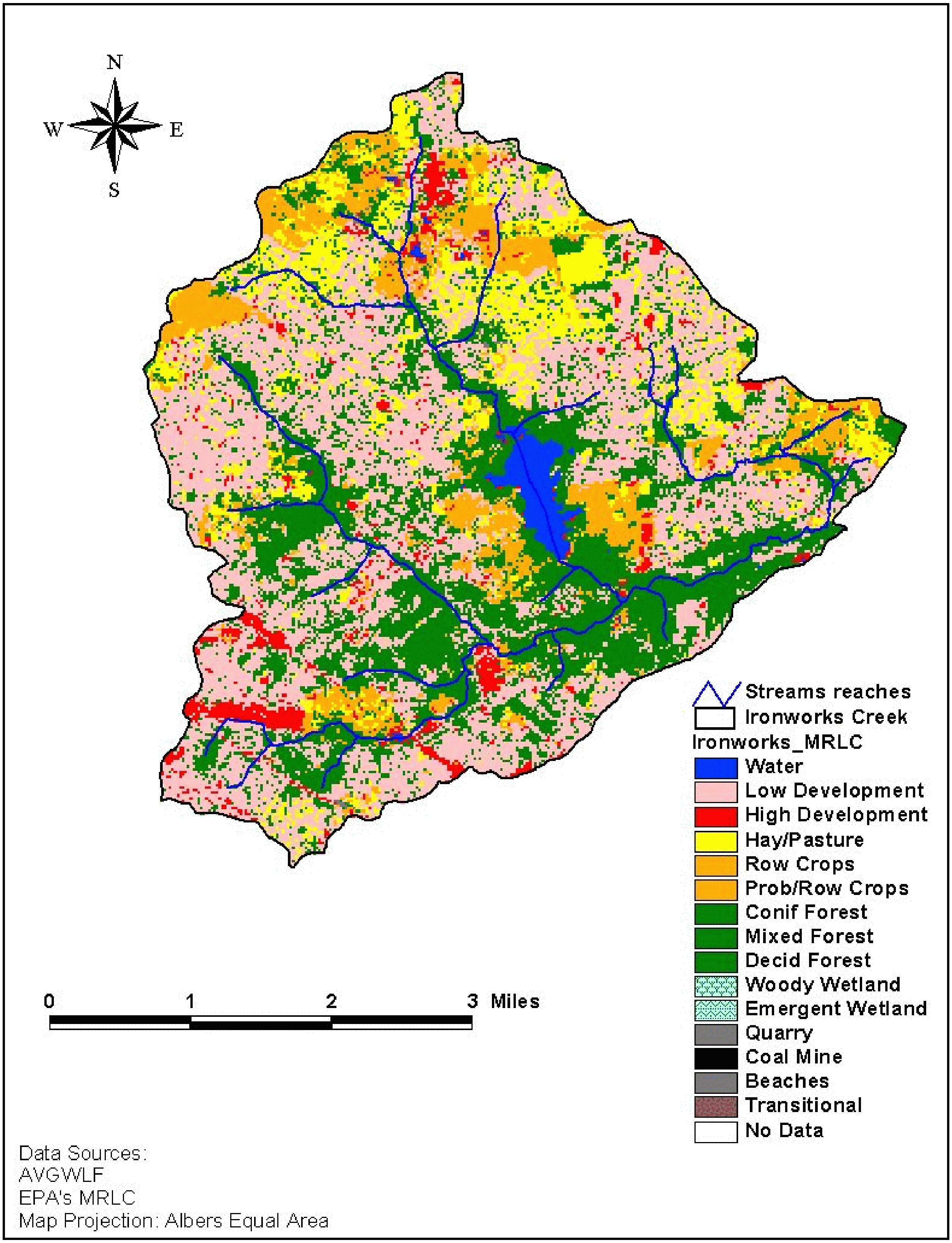

Figure 3-2. The reference watershed (Ironworks Creek) used in TMDL development for the Wissahickon Creek watershed

Table 3-1. Sediment endpoints determined for the Wissahickon Creek watershed

Subwatershed	303(d)-Listed Segment	TMDL Endpoint (Sediment lbs/yr)
1	971218-1345-ACE	1,935,056
	971218-1045-ACE	
	981015-1100-ACE	
	971217-1430-ACE	
2	971222-0930-ACE	7,436,463
	971222-1130-ACE	
	971217-1145-ACE	
	971216-1415-ACE	
	971217-1015-ACE	
3	971215-1133-ACE	4,103,923
	971215-1300-ACE	
	971215-1303-ACE	
4	971209-0930-ACE	6,667,594
	971208-1000-ACE	
	971211-1300-ACE	
	971215-1000-ACE	
	971215-1130-ACE	
5	971209-1430-ACE	7,330,365
	971209-1200-ACE	
	971208-1430-ACE	
	971208-1235-ACE	
	971208-1000-ACE	

4.0 TMDL Methodology and Calculation

Separate methodologies were utilized for determination of nutrient and siltation TMDLs. Each selected methodology considers specific impacts and conditions determined necessary for accurate source representation and system response.

4.1 Nutrient TMDL

The following sections discuss the methodology used for TMDL development and results in terms of TMDLs and required load reductions for each stream segment listed on Pennsylvania's 303(d) list as impaired due to nutrients.

4.1.1 Methodology

Results from analyses outlined in Section 2.2.1 describe the low-flow critical period associated with high observed nutrient concentrations. To determine a TMDL for Wissahickon Creek, a low-flow, steady-state model was utilized that included chemical and biological processes associated with nutrient enriched and eutrophic systems. A steady-state model was used to simulate conditions most likely occurring during a constant, low-flow scenario typical of periods when previously observed problems are prevalent and most critical. This low-flow, steady-state model inherently focused on point sources as the major source of nutrients to the Wissahickon Creek basin. Other potential sources (i.e., runoff from golf course irrigation, impacts from low-level dams, etc.) were assessed on a case-by-case basis, but no quantitative evidence justified the inclusion of such sources in the model under such low-flow conditions (see Section 2.1.3).

For nutrient TMDL development, two models were utilized to simulate the hydrodynamics and water quality of the basin. EPA's Environmental Fluid Dynamics Code (EFDC) was used to simulate hydrodynamics. The EFDC model is a general purpose modeling package for simulating three dimensional flow, transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software. To model water quality, a modified version of EPA's Water Quality Analysis Simulation Program (WASP5) used results from the hydrodynamic model to simulate those processes associated with nutrients, DO, and biological activity. Modifications to the WASP5 model included sub-routines accounting for biological processes associated with periphyton growth to account for impairment effects from algal growth. This version was configured by Hydraulic and Water Resources Engineers, Inc. (HWRE) as a subcontractor to Tetra Tech, Inc. for EPA Region 1 and Maine Department of Environmental Protection, and was refined by Tetra Tech, Inc. to provide accurate adaptation to Wissahickon Creek. Both EFDC and WASP5 have been applied successfully in numerous applications to rivers, lakes, and coastal waters, and are well-known and well-documented tools for mechanistically simulating the processes of concern in Wissahickon Creek.

An important step in the steady-state analysis of Wissahickon Creek was the identification of an appropriate critical low flow for the analysis. A standard flow often utilized for low-flow, steady-state analysis is the 7Q10 flow, defined as the streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval, or a 1 in 10 chance of occurring in any given year. A 7Q10 flow of 16.26 cfs was calculated for Wissahickon Creek based on flow records at the mouth (USGS gage 01474000). However, point source inputs to Wissahickon Creek, characterized in the model at design flows, exceed the calculated 7Q10 flow. Because the flow record used to calculate the 7Q10 inherently includes flow inputs from the point sources, this low flow was revised to identify the "background" 7Q10 flow at the mouth—the low flow not including influences from typical point source discharges. Further statistical analysis of flows throughout the watershed and those contributed from point sources was conducted, resulting in a critical low flow of 42.52 cfs at the mouth of Wissahickon Creek with dischargers at design flows (see the Modeling Report).

The modeling system for nutrient TMDL development was first configured and calibrated for low-flow conditions observed in summer 2002 using data collected by USGS, PA DEP, and major dischargers in the watershed. Once calibrated, the modeling system was configured for 7Q10 flow conditions to assess "baseline" conditions in the stream. To achieve water quality endpoints in the stream segments, multiple scenarios were modeled to account for varying discharge concentrations and conditions. Optimal results were reached that met instream water quality endpoints with minimal impact to stakeholders. However, reductions were required from dischargers so that these endpoints could be met. A detailed description of the background, configuration, and calibration of the modeling system is provided in the Modeling Report.

4.1.2 TMDL Calculation

TMDLs were established for each individual stream segment listed on Pennsylvania's 303(d) list. Each TMDL consists of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). These TMDLs identify the sources of pollutants that cause or contribute to the impairment of the DO criteria and allocate appropriate loadings to the various sources. Given the scientific knowledge available, and utilizing the model processes that describe the interrelationship of nutrients, carbonaceous oxygen demand (CBOD), sediment oxygen demand (SOD), and their impact on DO, it was determined necessary to prescribe TMDLs, LAs and WLAs for ammonia, nitrate and nitrite, ortho phosphate, and CBOD.

The equation used for TMDLs and allocations to sources is:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion is the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. For this study, the MOS is assumed implicit through conservative assumptions and the steady-state modeling approach of low flow conditions.

4.1.3 Waste Load Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. Of the twenty three National Pollution Discharge Elimination System (NPDES) permitted dischargers, only five were determined to require reductions to their NPDES permit limits for the pollutants considered.

The allocation process proceeded by reducing CBOD, ammonia nitrogen, nitrate and nitrite, and ortho phosphate loads from NPDES point sources until daily average and minimum daily DO criteria were satisfied. Reductions from each point source were determined on a case-by-case basis, with most reductions determined by local improvements downstream from the point of discharge. Where dischargers were in close proximity, sensitivity analyses were performed to ensure that appropriate sources received reductions. The Modeling Report provides details regarding the reduction procedure using the modeling system.

At the request of stakeholders, effluent water quality from Ambler Borough (PA0026603), Upper Gwynedd Township (PA0023256), Abington Township (PA0026867), Upper Dublin Township (PA0029441), and North Wales Borough (PA0022586) were modeled at DO concentrations of 7.0 mg/L, which is higher than levels presently specified by NPDES permits for each discharger. This was justified because higher DO concentrations are generally provided by these dischargers. However, allocations are dependent upon the higher DO from effluent flows, so reduction requirements will also require amendments to NPDES permits to ensure that DO concentrations of 7.0 mg/L are provided in the future.

These TMDLs recommend that the five aforementioned major dischargers have their NPDES permits modified when next reissued to reduce the amounts of CBOD, NH_3-N, NO_3+NO_2-N, and ortho PO_4 that may be discharged in the Wissahickon Creek basin. Specific concentrations for each facility and pollutant are listed in the TMDL tables of Appendix F.

4.1.4 Load Allocations

According to federal regulations (40 CFR 130.2(g)), load allocations are best estimates of the nonpoint or background loading. These allocations may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint sources should be distinguished (EPA, 2001).

Nonpoint source loads within the Wissahickon Creek basin were based on low-flow samples collected by PA DEP in summer 2002. Water quality samples were taken at upstream locations and select tributaries to estimate background loads. These loads were included in the calculations of TMDLs. However, no load reductions were determined necessary for background loads. As a result, stream segments 971215-1000-ACE (Lorraine Run), 971215-1300-ACE (headwaters of Pine Run), and 971217-1145-ACE (Trewellyn Creek) required no reductions for either WLAs nor LAs because no major point sources were present and water quality data did not suggest that such reductions were warranted. However, to address the impairments in these stream segments, implementation measures are recommended in Section 5.1 to address non-source related factors that can result in biological improvements.

Although the majority of nutrient loads to stream segment 971209-0930-ACE (bottom of the Wissahickon Creek mainstem) were from upstream segments and considered nonpoint source, reductions to these upstream segments were reached in meeting their TMDLs. As a result of upstream reductions, stream segment 971209-0930-ACE met the DO criteria and no reductions were required for sources within this stream segment to meet the TMDL.

4.1.5 TMDL Results and Allocations

TMDLs were developed for each of the seasonal water quality criteria for DO applicable to the Wissahickon Creek basin and include: (1) Trout Stocking (TS) from February 15 to July 31, and (2) Warm Water Fishes (WWF) for the remainder of the year (see Table 1-3). For each stream segment in the Wissahickon Creek basin included in Pennsylvania's 303(d) list due to nutrients (Figure 4-1), separate TMDLs, WLAs, and LAs were determined and are summarized in Tables 4-1 and 4-2 for both TS and WWF periods, respectively. Total loads were determined for $CBOD_5$, ammonia nitrogen, nitrate-nitrite nitrogen, and ortho phosphate. A complete list of individual WLAs, LAs, and TMDLs for each stream segment and seasonal DO criteria are provided in Appendix F.

For each of the five major dischargers, WLAs are listed in Tables 4-3 and 4-4 for TS and WWF DO criteria, respectively. A negative "percent reduction" signifies that more load is allocated than the concentration observed in the effluent during the summer 2002 monitoring period. WLAs are specific to the summer period. For the remainder of the year, implementation of WLAs require seasonal adjustments following PA DEP procedures (PA DEP, 1997). For more detail, see Section 5.

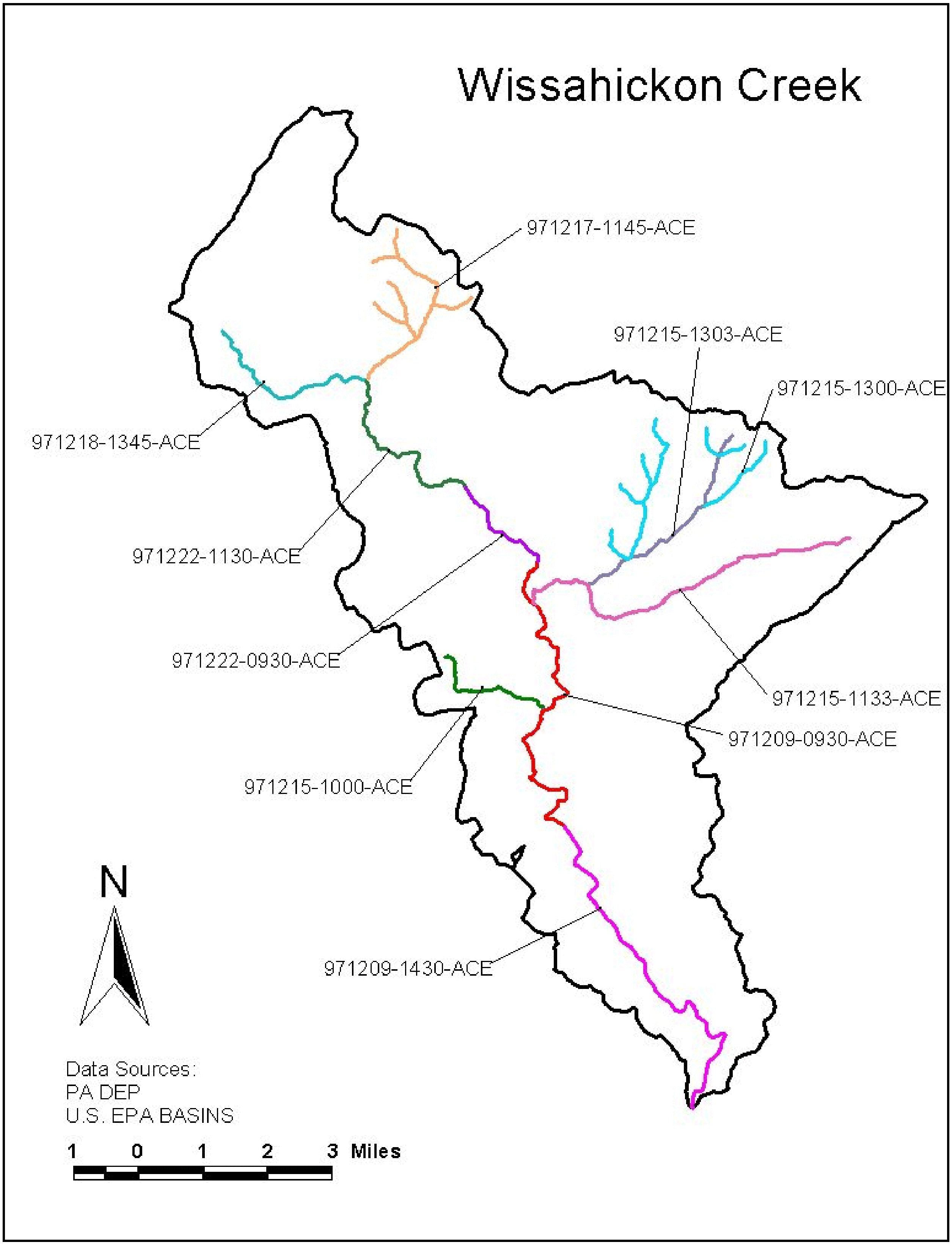

Figure 4-1. Stream segments of the Wissahickon Creek basin listed for nutrients

Table 4-1. TMDL summary by stream segment for the Wissahickon Creek basin - Trout Stocking (February 15 to July 31)

Sum of Waste Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	258.753	38.509	1058.378	97.398
Wissahickon Creek	971209-1430-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-0930-ACE	1.034	0.202	0.321	0.046
Wissahickon Creek	971222-0930-ACE	543.402	81.466	1657.755	254.221
Wissahickon Creek	971222-1130-ACE	0.000	0.000	0.000	0.000
Lorraine Run	971215-1000-ACE	0.118	0.022	0.052	0.006
Sandy Run	971215-1133-ACE	244.684	23.571	986.281	60.511
Pine Run	971215-1300-ACE	0.000	0.000	0.000	0.000
Pine Run	971215-1303-ACE	120.803	10.747	335.664	14.963
Trewellyn Creek	971217-1145-ACE	0.000	0.000	0.000	0.000
Sum of Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-1430-ACE	835.590	93.169	4064.599	404.039
Wissahickon Creek	971209-0930-ACE	1062.281	122.283	4120.542	415.253
Wissahickon Creek	971222-0930-ACE	159.364	20.025	1033.639	90.568
Wissahickon Creek	971222-1130-ACE	222.733	33.223	1050.113	95.465
Lorraine Run	971215-1000-ACE	123.732	1.344	134.480	1.949
Sandy Run	971215-1133-ACE	114.575	9.822	336.806	14.787
Pine Run	971215-1300-ACE	1.181	0.040	0.986	0.100
Pine Run	971215-1303-ACE	1.181	0.040	0.986	0.100
Trewellyn Creek	971217-1145-ACE	1.922	0.049	0.162	0.029

Table 4-2. TMDL summary by stream segment for the Wissahickon Creek basin - Warm Water Fishes (August 1 to February 14)

Sum of Waste Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	445.052	86.405	1051.573	170.411
Wissahickon Creek	971209-1430-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-0930-ACE	1.034	0.202	0.321	0.046
Wissahickon Creek	971222-0930-ACE	543.402	81.466	1646.820	254.221
Wissahickon Creek	971222-1130-ACE	0.000	0.000	0.000	0.000
Lorraine Run	971215-1000-ACE	0.118	0.022	0.052	0.006
Sandy Run	971215-1133-ACE	326.145	65.235	986.281	150.935
Pine Run	971215-1300-ACE	0.000	0.000	0.000	0.000
Pine Run	971215-1303-ACE	137.319	22.868	300.307	21.062
Trewellyn Creek	971217-1145-ACE	0.000	0.000	0.000	0.000
Sum of Load Allocations					
Segment Name	Segment ID	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4 (lbs/day)
Wissahickon Creek	971218-1345-ACE	0.000	0.000	0.000	0.000
Wissahickon Creek	971209-1430-ACE	973.035	167.356	4031.623	559.839
Wissahickon Creek	971209-0930-ACE	1239.972	206.190	4080.025	575.352
Wissahickon Creek	971222-0930-ACE	278.761	58.710	1032.974	159.435
Wissahickon Creek	971222-1130-ACE	383.300	77.696	1045.820	167.137
Lorraine Run	971215-1000-ACE	123.732	1.344	134.480	1.949
Sandy Run	971215-1133-ACE	130.034	21.600	301.853	20.805
Pine Run	971215-1300-ACE	1.181	0.040	0.986	0.100
Pine Run	971215-1303-ACE	1.181	0.040	0.986	0.100
Trewellyn Creek	971217-1145-ACE	1.922	0.049	0.162	0.029

Table 4-3. WLAs for five major dischargers in the Wissahickon Creek watershed - Trout Stocking (February 15 to July 31)

Name	NPDES	CBOD5 (mg/L)	NH3-N (mg/L)	NO3+NO2-N (mg/L)	Ortho PO4-P (mg/L)	TMDL Percent Reduction			
						CBOD5[A]	NH3-N[A]	NO3+NO2-N[B]	Ortho PO4-P[B]
North Wales Boro	PA0022586	3.00	0.50	15.16	1.41	70.0%	80.0%	0.0%	70.0%
Upper Gwynedd Township	PA0023256	5.00	0.74	20.08	1.82	50.0%	59.0%	-38.0%	49.0%
Ambler Boro	PA0026603	10.00	1.50	30.52	4.68	0.0%	0.0%	-51.1%	0.0%
Abington Township	PA0026867	7.50	0.72	30.27	1.85	25.0%	64.0%	0.0%	60.0%
Upper Dublin Township	PA0029441	13.21	1.18	36.71	1.64	11.9%	53.0%	-90.0%	28.8%

A - Calculated from NPDES permit limit
B - Calculated from average of summer 2002 monitoring

Table 4-4. WLAs for five major dischargers in the Wissahickon Creek watershed - Warm Water Fishes (August 1 to February 14)

Name	NPDES	CBOD5 (mg/L)	NH3-N (mg/L)	NO3+NO2-N (mg/L)	Ortho PO4-P (mg/L)	TMDL Percent Reduction			
						CBOD5[A]	NH3-N[A]	NO3+NO2-N[B]	Ortho PO4-P[B]
North Wales Boro	PA0022586	5.90	1.37	21.22	2.40	41.0%	45.0%	-40.0%	49.0%
Upper Gwynedd Township	PA0023256	8.50	1.62	19.05	3.22	15.0%	10.0%	-30.9%	9.9%
Ambler Boro	PA0026603	10.00	1.50	30.31	4.68	0.0%	0.0%	-50.1%	0.0%
Abington Township	PA0026867	10.00	2.00	30.27	4.63	0.0%	0.0%	0.0%	0.0%
Upper Dublin Township	PA0029441	15.00	2.50	32.85	2.30	0.0%	0.0%	-70.0%	0.0%

A - Calculated from NPDES permit limit
B - Calculated from average of summer 2002 monitoring

4.1.6 Consideration of Critical Conditions

Federal Regulations (40 CFR 130.7(c)(1)) require TMDLs to consider critical conditions for streamflow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality in waterbodies are protected during periods when they are most vulnerable. Critical conditions include combinations of environmental factors that result in attaining and maintaining the water quality criteria and have an acceptably low frequency of occurrence (USEPA, 2001).

TMDLs for Wissahickon Creek adequately address critical conditions for flow through analysis of 7Q10 conditions in the basin. Analysis of 7Q10 conditions and flow budget for the basin are described in the Modeling Report. For such a low flow period, most of the Wissahickon Creek streamflow is dominated by point source flows. Upstream of Route 73, dischargers account for almost 100 percent of flow. During low flow periods, nutrient concentrations are historically higher, but dissolved oxygen concentrations are lower (see Section 2.1.1).

Critical conditions for nutrient loads were considered by determining WLAs based on maximum flows from dischargers set by design flows specified in NPDES permits for each facility. Under normal summer conditions, the cumulative discharge flow ranges from 50 to 60 percent of combined design flows. Use of design flows in TMDL determination provides additional assurance that when design flows are reached, the water quality in the stream will meet water quality criteria.

Water quality standards for DO vary seasonally for the Wissahickon Creek basin as a result of trout stocking. Higher standards for DO are specified for less than a 6 month period from February 15 through July 31. This period of more stringent criteria was considered an essential distinction of critical conditions for the basin.

4.1.7 Consideration of Seasonal Variation

As shown in Section 2.1.1, higher nutrient concentrations typically occur during the summer low-flow period. The low-flow period has a reduced assimilative capacity of discharges due to less streamflow available for dilution. Also, the activity of aquatic biota varies seasonally as a function of streamflow and temperature, with higher impacts associated with warmer, low-flow conditions. Since biological activity was an important consideration in Pennsylvania's original listing of the stream segments as impaired due to nutrients, attention to the summer low-flow period was critical. If the stream segments are protected during this critical period, then other periods of lower temperatures, less biological activity, and more assimilative streamflow capacity are inherently assumed protected.

Seasonal DO criteria were also considered in TMDL analysis. Separate TMDLs were developed for the 6 month period from February 15 through July 31 for trout stocking and the remainder of the year designated for warm water fish.

4.2 Siltation TMDLs

The following sections discuss the methodology used for TMDL development as well as the results of the TMDL study. The TMDL results include the load reductions required for each stream segment listed on Pennsylvania's 303(d) list as impaired due to siltation.

4.2.1 Methodology

Results of analysis reported in Section 2.2.1 show that most siltation is likely to occur during wet weather. To develop a siltation TMDL for the impaired reaches in the basin, a "reference watershed approach" was utilized (see Section 3 and Appendix E). Once the impaired and reference watersheds were matched, a watershed model was used to simulate the sediment loads from different sources. The watershed model used for this study was AVGWLF, a modified version of the Generalized Watershed Loading function (GWLF) model (Haith and Shoemaker, 1987). GWLF has been used by Pennsylvania in developing numerous TMDLs including Donegal Creek and Conodoguinet Creek (Tetra Tech, Inc, 2000). The input data for AVGWLF was generated by a GIS interface developed by the Environmental Resources Research Institute of the Pennsylvania State University. To estimate loads from streambank erosion, AVGWLF includes empirical routines that consider such factors as length of stream and land use practices.

For TMDL development, the model was applied to both the impaired and reference watersheds, and results were compared with available monitoring data in the impaired watershed. The sediment loads calculated for the reference watersheds were used as endpoints for the impaired watersheds. TMDLs were then developed for the impaired watersheds based on the endpoints. A general description of the approach is shown in Figure 4-1. Appendix E details the technical approach and outlines the model configuration, calibration, and procedures for TMDL development and source reductions.

4.2.2 TMDL Calculation

TMDLs were established for each individual stream segment listed on Pennsylvania's 303(d) list. Each TMDL consists of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). These TMDLs identify the sources of pollutants that cause or contribute to the siltation impairment and allocate appropriate loadings to the various sources.

The equation used for developing TMDLs is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion is the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. For this study, an explicit MOS of 10 percent is applied.

4.2.3 Waste Load Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. Of the 13 NPDES dischargers permitted to discharge specific amount of sediment (measured as TSS), none required reductions to their NPDES permit limits (e.g., treated sewage effluents). Based on available discharge monitoring reports (DMR) the average discharge of sediment from such facilities in the watershed was usually well below the permitted TSS concentration.

Stormwater permits typically do not have numeric limits on sediment. EPA's stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from separate storm sewer systems (MS4s). For these discharges, WLAs were determined using land-use-specific, unit area loads determined in modeling analysis for specific regions of the Wissahickon Creek basin, as well as the streambank erosion within each municipality. As discussed in greater detail in Appendix E, the Wissahickon Creek watershed was divided into five main subwatersheds in order to match the impaired watershed with the smaller reference watershed Ironworks Creek. Sediment loads were estimated for each of the five subwatersheds and then distributed among municipalities as MS4 stormwater permit loads (WLAs) for each individual 303(d)-listed watershed. Distribution of loads was accomplished within the five subwatersheds for all 303(d) listed watersheds and municipalities based on the corresponding unit area loading (lbs/acre/year) and streambank erosion (lbs/year)

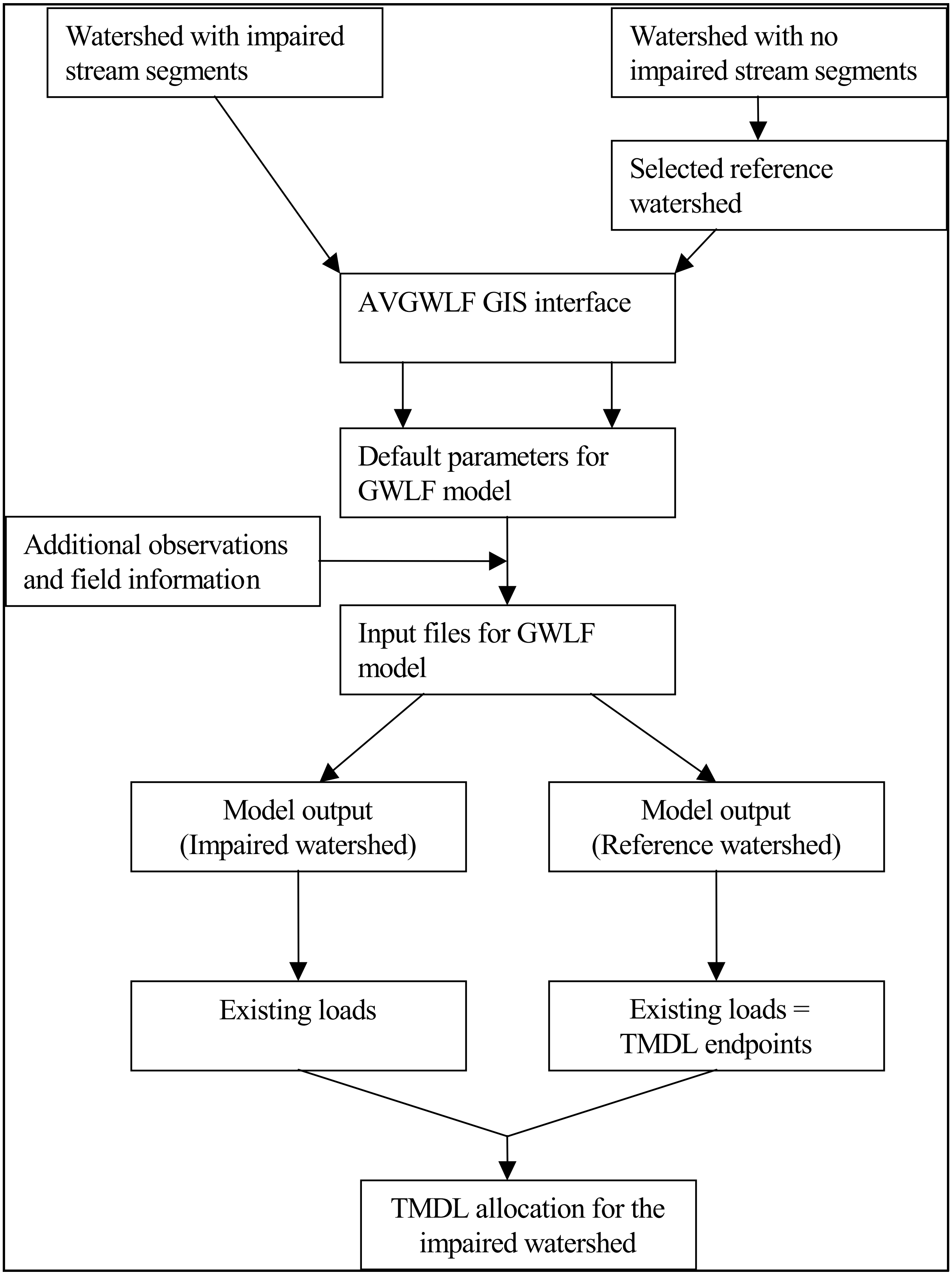

Figure 4-2. General description of approach for siltation TMDL development

determined in modeling analysis. Figure 4-3 presents the five main subwatersheds and Figure 4-4 presents the 303(d)-listed watersheds throughout the entire Wissahickon Creek watershed. Table 4-5 presents the listed watersheds within each of the five modeled subwatersheds. A GIS coverage of municipal boundaries was obtained from the Pennsylvania Spatial Data Access (PASDA) and presented in Figure 2-2.

Table 4-5. Watersheds impaired by siltation within each of the five modeled subwatersheds

Subwatershed	Impaired Segment
1	971218-1345-ACE
	971218-1045-ACE
	981015-1100-ACE
	971217-1430-ACE
2	971222-0930-ACE
	971222-1130-ACE
	971217-1145-ACE
	971216-1415-ACE
	971217-1015-ACE
3	971215-1133-ACE
	971215-1300-ACE
	971215-1303-ACE
4	971209-0930-ACE
	971208-1000-ACE
	971211-1300-ACE
	971215-1000-ACE
	971215-1130-ACE
5	971209-1430-ACE
	971209-1200-ACE
	971208-1430-ACE
	971208-1235-ACE
	971208-1000-ACE

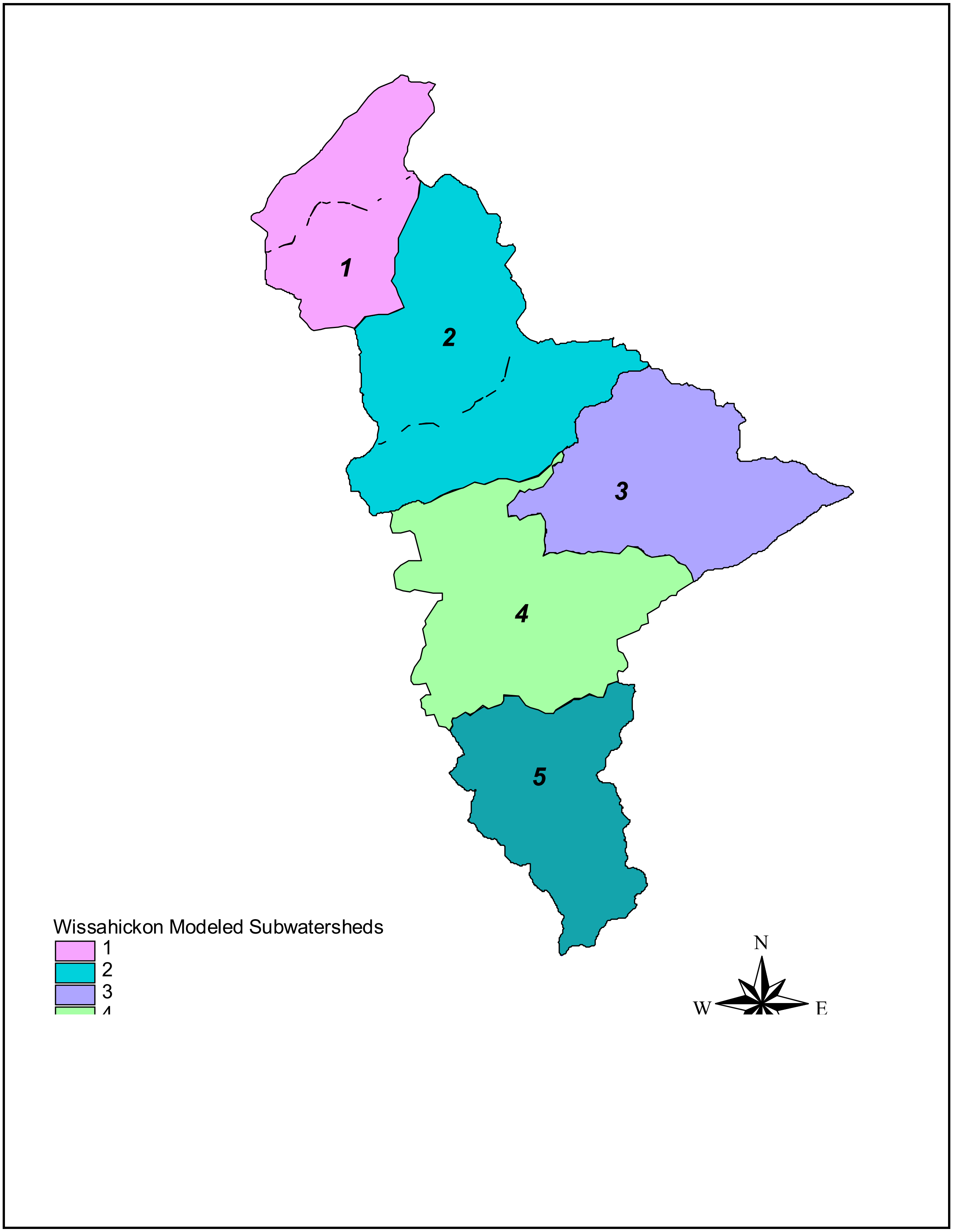

Figure 4-3. Five main subwatersheds in the Wissahickon Creek watershed

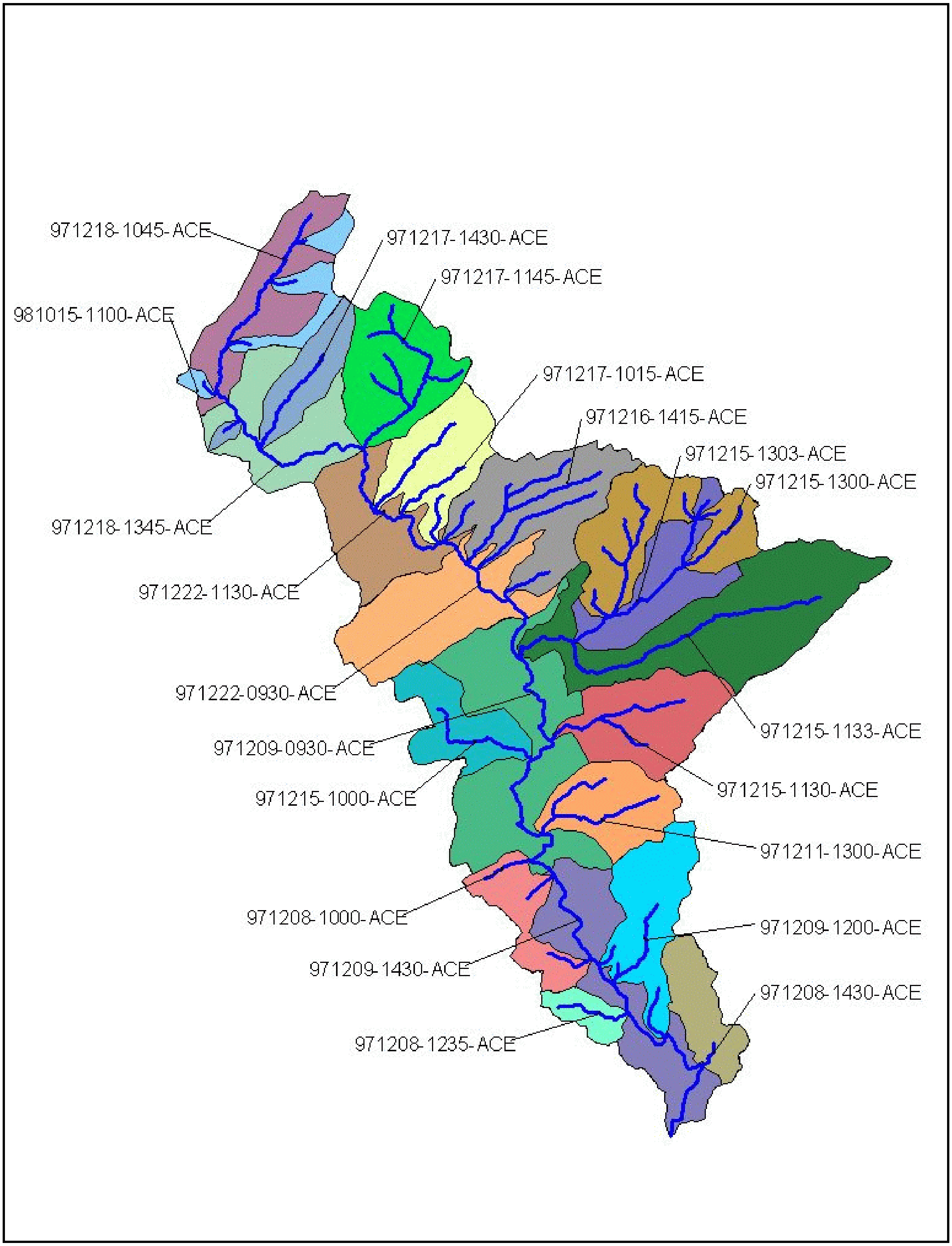

Figure 4-4. Watersheds listed for siltation in the Wisahickon Creek watershed

4.2.4 Load Allocations

According to federal regulations (40 CFR 130.2(g)), load allocations are best estimates of the nonpoint source and background loading. These allocations may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint sources should be distinguished (EPA, 2001).

The Wissahickon basin was divided into 5 subwatersheds (see Figure 4-3) to better match the reference watershed size. The upstream load (i.e., the loads from subwatersheds 1, 2, and 4 into subwatersheds 2, 4, and 5, respectively) were the only sediment loads in the watershed that received LAs in the Wissahickon Creek basin.

4.2.5 TMDL Results and Allocations

Since the Wissahickon Creek watershed was divided into 5 smaller subwatersheds (see Figure 4-3) to better match the reference watershed size, sediment allocations began at the top of the watershed (i.e., subwatershed 1) and continued downstream to the mouth of the watershed (i.e., subwatershed 5). After sediment reductions were made to the first subwatershed (subwatershed 1) based on the sediment load in the reference watershed, the resulting reduced sediment load was added to the next downstream subwatershed (subwatershed 2) to represent the in-stream sediment load coming from upstream. The sediment load coming from subwatershed 1 was subjected to the sediment delivery ratio (SDR) for subwatershed 2 to account for natural losses. The same upstream load was also added to the reference watershed to account for loading from upstream. The total sediment load in the subwatershed was then compared to the reference watershed sediment load so that reductions could be made. This process continued downstream to the mouth of the Wissahickon Creek watershed. As the reduced sediment loads from upstream Wissahickon Creek were added to the downstream subwatersheds, no further reductions were made to the upstream loads since they were already meeting the appropriate reference watershed sediment target.

For each stream segment in the Wissahickon Creek basin included on Pennsylvania's 303(d) list due to siltation (Figure 4-4), separate TMDLs, WLAs, and LAs were determined . Total sediment loads from landuses within the Wissahickon Creek watershed were based on unit area loadings for each landuse (Table 4-6). The streambank erosion sediment load was distributed to each of the listed segments in the appropriate watershed based on the drainage area of each listed segment (i.e., if a particular listed watershed made up 12 percent of the larger modeled subwatershed, it received 12 percent of the streambank erosion load). TMDLs are summarized by listed segment in Tables 4-7 through 4-11. Note that in Tables 4-7 through 4-11, the WLA is presented in two different ways. In order to meet the reference watershed sediment loads that were determined to be the TMDL endpoints for each of the five modeled subwatersheds, the loads from NPDES dischargers were multiplied by the SDR in each of the respective watersheds.

This resulted in accounting for transport losses of the sediment from the dischargers as it travels through the watershed. The WLA (SDR applied) represents the sediment load from dischargers at the mouth of the watershed after the SDR has been applied. The WLA (SDR not applied) represents the sediment load at the "end of pipe" for each of the dischargers and was based on the permitted flow and TSS concentrations (which were converted to lbs/yr). None of the NPDES sediment dischargers in the watershed require reductions. The lower WLA with the SDR applied accounts for natural losses as the sediment moves through the watershed.

Each municipal source (MS4 stormwater permit) (Figure 2-2) received a WLA based on the sediment loading from landuses and streambank erosion within the municipal boundaries. The individual WLAs for each municipal area are presented as a total for each township in Table 4-12. Appendix G provides the TMDLs in greater detail for each impaired stream segment (i.e., loads distributed by source).

Table 4-6. Unit area loading rates for sediment by landuse

	Unit Area Loading Rate (lbs/acre/yr)				
	Subwatershed 1	Subwatershed 2	Subwatershed 3	Subwatershed 4	Subwatershed 5
Low-Intensity Residential	164.62	173.45	180.50	258.93	420.17
High-Intensity Residential/Urban	139.41	129.28	137.11	106.22	278.76
Hay/Pasture	51.60	48.02	76.84	42.54	108.17
Row Crops	464.28	301.79	306.60	254.55	623.34
Coniferous Forest	3.13	2.74	4.94	5.74	8.82
Mixed Forest	3.99	3.93	5.67	4.81	9.43
Deiduous Forest	5.43	4.58	7.00	8.69	32.00
Quarry	0.00	0.00	0.00	619.45	0.00
Coal Mines	0.00	0.00	0.00	352.72	0.00
Transitional	0.00	0.00	526.14	751.42	12931.69

Table 4-7. TMDLs for impaired watersheds within subwatershed 1

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971217-1430-ACE North Wales Tributary	0.00	314,395.17	314,395.17	37,008.28	351,403.45
971218-1045-ACE Wissahickon Creek	0.00	541,006.02	541,006.02	65,618.03	606,624.04
971218-1345-ACE Wissahickon Creek	0.00	1,143,328.37	653,603.61	63,680.25	717,283.86
981015-1100-ACE Tributary Upstream of North Wales Tributary	0.00	232,545.90	232,545.90	27,199.07	259,744.97
TOTAL	**0.00**	**2,231,275.46**	**1,741,550.69**	**193,505.63**	**1,935,056.33**

*See explanation in above paragraph

Table 4-8. TMDLs for impaired watersheds within subwatershed 2

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971216-1415-ACE Rose Valley Tributary	0.00	2,129,859.87	1,624,973.22	180,826.73	1,805,799.95
971217-1015-ACE Willow-Run East	0.00	999,101.77	999,101.77	114,987.28	1,114,089.06
971217-1145-ACE Trewellyn Creek	0.00	1,254,520.88	1,254,520.88	148,082.99	1,402,603.87
971222-0930-ACE Wissahickon Creek	0.00	1,471,917.14	1,471,917.14	170,572.56	1,642,489.70
971222-1130-ACE Wissahickon Creek	0.00	1,052,045.58	1,052,045.58	126,274.19	1,178,319.77
Upstream Load**	290,258.45	0.00	0.00	2,902.58	293,161.03
TOTAL	**290,258.45**	**6,907,445.25**	**6,402,558.59**	**743,646.34**	**7,436,463.38**

*See explanation in above paragraph
**Upstream load includes the TMDL load from subwatershed 1

Table 4-9. TMDLs for impaired watersheds within subwatershed 3

Subwatershed	LA	WLA (SDR not applied)	WLA (SDR applied)	MOS	TMDL
971215-1133-ACE	0.00	2,200,406.01	1,903,213.83	210,322.46	2,113,536.29

Sandy Run					
971215-1300-ACE Pine Run	0.00	1,056,328.02	1,056,328.02	119,072.41	1,175,400.43
971215-1303-ACE Pine Run	0.00	817,420.56	733,988.61	80,997.40	814,986.01
TOTAL	**0.00**	**4,074,154.58**	**3,693,530.45**	**410,392.27**	**4,103,922.72**

*See explanation in above paragraph

Table 4-10. TMDLs for impaired watersheds within subwatershed 4

Subwatershed	LA (lbs/yr)	WLA (SDR not applied)* (lbs/yr)	WLA (SDR applied)* (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971208-1000-ACE Wises Mill Tributary	0.00	134,634.68	134,634.68	16,197.25	150,831.92
971209-0930-ACE Wissahickon Creek	0.00	1,603,902.60	1,602,534.82	191,195.19	1,793,730.01
971211-1300-ACE Paper Mill Run	0.00	599,040.65	599,040.65	73,990.17	673,030.82
971215-1000-ACE Lorraine Run	0.00	1,330,422.12	622,454.00	59,816.67	682,270.66
971215-1130-ACE Tributary Downstream of Sandy Run	0.00	784,241.10	784,241.10	96,477.59	880,718.70
Upstream Load**	1,961,865.64	0.00	0.00	196,186.56	2,158,052.20
TOTAL	**1,961,865.64**	**4,452,241.14**	**3,742,905.24**	**633,863.43**	**6,338,634.32**

*See explanation in above paragraph

**Upstream load includes the TMDL load from subwatersheds 2 and 3

Table 4-11. TMDLs for impaired watersheds within subwatershed 5

Subwatershed	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	TMDL (lbs/yr)
971208-1235-ACE Valley Road Tributary	0.00	230,185.11	25,338.69	255,523.81
971208-1430-ACE Monoshone Creek	0.00	519,867.90	59,260.72	579,128.61
971209-1200-ACE Creshiem Creek	0.00	885,240.83	101,969.27	987,210.10
971209-1430-ACE Wissahickon Creek	0.00	1,133,903.32	133,402.74	1,267,306.06
971208-1000-ACE Wises Mill Tributary	0.00	357,050.74	40,418.87	397,469.61
Upstream Load*	1,172,647.35	0.00	117,264.74	1,289,912.09
TOTAL	**1,172,647.35**	**3,126,247.90**	**477,655.03**	**4,776,550.28**

*Upstream load includes the TMDL load from subwatershed 4

Table 4-12. Summary of sediment wasteload allocations for streambank erosion and overland load by municipality (MS4)

Municipality	Existing Load from Streambank Erosion (lbs/yr)	Streambank Erosion WLA (lbs/yr)	Percent Reduction for Streambank Erosion	Existing Overland Load (lbs/yr)	Overland Load WLA (lbs/yr)	Percent Reduction for Overland Load (lbs/yr)	TOTAL WLA (lbs/yr)
Abington	1,761,691.55	966,571.26	45.13%	362,538.56	103,130.74	71.55%	1,069,702.00
Ambler	510,945.64	280,326.36	45.14%	75,008.50	20,295.79	72.94%	300,622.15
Cheltenham	419,005.33	62,200.67	85.16%	20,549.46	5,232.99	74.53%	67,433.66
Horsham	65,916.23	36,872.33	44.06%	5,764.44	1,661.66	71.17%	38,533.99
Lansdale	143,869.79	85,245.50	40.75%	60,295.96	34,742.91	42.38%	119,988.41
Lower Gwynedd	4,553,127.66	2,508,287.00	44.91%	575,510.64	278,900.79	51.54%	2,787,187.79
Montgomery	495,212.28	281,881.69	43.08%	135,550.26	75,599.47	44.23%	357,481.17
North Wales	120,672.51	71,500.69	40.75%	50,070.60	26,583.53	46.91%	98,084.21
Philadelphia	12,663,015.42	2,698,965.79	78.69%	1,413,863.47	556,055.54	60.67%	3,255,021.33
Springfield	8,820,980.83	1,412,838.69	83.98%	700,517.47	207,495.15	70.38%	1,620,333.84
Upper Dublin	5,637,974.97	3,301,727.13	41.44%	906,098.66	366,831.23	59.52%	3,668,558.35
Upper Gwynedd	1,052,200.69	622,996.97	40.79%	430,432.57	307,574.17	28.54%	930,571.14
Upper Moreland	12,688.24	8,395.74	33.83%	1,303.29	568.46	56.38%	8,964.20
Whitemarsh	10,378,633.34	1,843,187.80	82.24%	538,078.65	274,715.43	48.95%	2,117,903.24
Whitpain	3,184,580.09	1,625,769.94	48.95%	357,776.46	200,063.92	44.08%	1,825,833.86
Worcester	20,407.49	12,091.81	40.75%	10,644.84	8,638.72	18.85%	20,730.53

4.2.6 Critical Conditions

The GWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Because there is usually a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody. Accounting for annual conditions ensures protection of Wissahickon Creek and tributaries through consideration of all seasonally variable hydrologic conditions, including extended wet periods, periods associated with isolated storms, and dry periods with intermediate rainfall events. By basing the TMDL on annual average conditions, both high and low flow conditions were taken into account, as well as seasonality.

4.2.7 Seasonal Variation

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The combination of these model features accounts for seasonal variability. As mentioned in the previous section, by basing the TMDL on annual average conditions, both high and low flow conditions were taken into account, as well as seasonality.

5.0 Reasonable Assurance and Implementation

Development of TMDLs is only the beginning of the process for stream restoration and watershed management. Load allocations to point and nonpoint sources serve as targets for improvement, but success is determined by the level of effort put forth in making sure that those goals are achieved. Load reductions proposed by nutrient and siltation TMDLs require specific watershed management measures to ensure successful implementation.

5.1 Nutrient TMDL

Implementation of best management practices (BMPs) in conjunction with waste load reductions from point sources should achieve the loading reduction goals established in the TMDLs. Further "ground truthing" should be performed in order to assess both the extent of existing BMPs, and to determine the most cost-effective and environmentally protective combination of BMPs required for meeting the nutrient reductions outlined in this report.

For stream segments of Trewellyn Creek (971217-1145-ACE), Lorraine Run (971215-1000-ACE), and headwaters of Pine Run (971215-1300-ACE), no reductions from point sources were necessary because either none were present or data was not available to suggest that DO criteria were not being met. For these segments, it is assumed that biological conditions in the stream are most likely caused by environmental factors that can be remedied through proper management techniques, rather than a result of load reductions in the stream. Specific BMPs are suggested by EPA to provide assurance that biological improvements are provided for these stream segments. Poor biological conditions are considered to be controlled by two primary factors for these segments: (1) extremely shallow conditions in the stream caused by lack of baseflow, and (2) lack of sufficient shading to naturally reduce the biological activity stimulated by higher water temperatures resulting from exposure to direct sunlight. To provide additional baseflow for the low-flow period, BMPs are recommended that encourage infiltration through either stormwater retention or stream buffer zones. Such management practices would also address those stream segments of the Wissahickon Creek basin included on the 303(d) list as a result of impairments associated with water/flow variability. To increase shading, EPA recommends that additional tree canopy be provided along the stream banks.

Several other stream segments will benefit from similar BMPs in conjunction with upstream waste load reductions. Additional tree canopy can potentially reduce biological activity causing diurnal variability of DO concentrations resulting in violations of water quality standards. In addition, BMPs that seek to increase baseflow can result in additional assimilative capacity of the stream for point source discharges.

The nutrient TMDL and WLAs reported herein are contingent on the assumption that NPDES permits for the five significant municipal facilities increase the effluent DO concentrations to 7.0 mg/L as a daily minimum. To provide flexibility in implementation, TMDLs and WLAs were determined for several scenarios: (1) all major discharges with DO levels at 6.0 mg/L (includes required increases from Ambler Borough and Abington Township), and (2) all major dischargers with DO levels at 7.0 mg/L, 3) all major dischargers with DO levels at 7.5 mg/L, 4) all major dischargers with DO levels at 7.75 mg/L, and 5) all major dischargers with DO levels at 8.0

mg/L. These scenarios will be used as guidance for reissuing NPDES permits so that the TMDLs are met. The reader is referred to Appendix D of this report for a discussion of the WLAs required to attain and maintain state water quality standards for each of the above scenarios. EPA recommends that WLAs and amendments to permit limits be based on the concentrations specified in Tables 4-3 and 4-4. However, the concentrations presented in Appendix D could also be considered as viable options for the permitting authority. These would ensure protection of the stream segments under all varying seasonal and hydrology conditions.

This TMDL considered the implementation of seasonal limits. Chapter 4 of this report presents the recommended allocations to two seasonal periods for which this TMDL is applicable. In addition, Pennsylvania Department of Environmental Protection (DEP) has established a seasonal effluent limitations strategy for permitting point sources. This strategy is documented in DEPs policy "Determining Water Quality-based Effluent Limits", December 9, 1997. This strategy establishes a set of seasonal "multipliers" for various conventional and non-conventional pollutants. The following table provides these multipliers for the pollutants covered under this TMDL. Note that the state has not included a multiplier for dissolved oxygen or nitrite-nitrate (NO2-NO3). For this TMDL, EPA has assumed that the multiplier for NO2-NO3 is the same as the one for phosphorus.

Table 5.1A - Seasonal Multipliers based on DEPs Seasonal Effluent Limitations Strategy

Parameter	Seasonal Time Period	Winter Limit Multiplier
BOD	Nov 1 - Apr 30	2.0
Phosphorus	Nov1 - Mar 31	2.0
Ammonia	Nov 1 - Apr 30	3.0

Based on these multipliers, and seasonal time periods, for the pollutants of concern, 'winter' limits were determined. Note that this TMDL did not include water quality modeling for the 'winter' period and the 'winter' limits shown below are based solely on DEP's strategy. Modifications to these 'winter' limits can be made no impact on this TMDL. Tables 5.1B and 5.1C below provide the 'winter' limits for the five significant municipal facilities considered in this TMDL. These winter limits are based on two separate periods. Since the trout stocking standard applies from mid-February through June, the winter multipliers for the period mid-February to May 1 for BOD and mid-February through April 1 for Phosphorus and NO2-NO3 were applied to the allocations determined for the low flow stocking period. The warm water fishes standard applies from July through mid-February so the winter multipliers for the period November to mid-February for BOD and November through mid-February for Phosphorus and NO2-NO3 were applied to the allocations determined for the low flow warm water fishes period

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Table 5.1B - Seasonal Limits based on Pennsylvania's Strategy (mg/L)

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
BOD (Nov 1 - Feb 15)	11.8	17	20	20	30
BOD (Feb 15 - April 30)	6.0	10.0	20.0	15.0	25.5
Ortho P (Nov 1 - Feb 15)	4.8	6.4	9.4	9.3	4.6
Ortho P (Feb 15 - March 31)	2.8	3.2	9.1	3.1	3.7
NO2-NO3 (Nov 1 - Feb 15)	No Limit	No Limit	No Limit	No Limit	No Limit
NO2-NO3 (Feb 15 - March 31)	No Limit	No Limit	No Limit	No Limit	No Limit
NH3 (Nov 1 - Feb 15)	4.1	4.9	4.5	6	7.5
NH3 (Feb 15 - April 30)	1.5	2.22	4.5	2.16	6.75

As shown in results reported in the Modeling Report, lower portions of Wissahickon Creek benefit from flows provided by Coorson's Quarry. Under current loading conditions, if quarry flows cease, the modeling system predicts that without TMDL load reductions, additional violations in the DO standards are likely to occur. Similar analysis was performed for TMDL allocations during the Trout Stocking period and results showed that if Coorson's Quarry decreases effluent flow to the minimum allowed (0.5 cfs) in their NPDES permit (revised in permit reissued in April 2003)), no additional DO violations occur (Appendix D).

To provide additional assurance that TMDLs are protective of the designated uses of the Wissahickon Creek basin, analysis was performed to ensure that WLAs for ammonia did not result in violations of water quality criteria. The ammonia standard is calculated based on pH and water temperature. During summer 2002, the median pH was 7.45 and the median water temperature was 23.9 degrees C. Under these conditions, the following instream criteria were calculated from PA standards:

Max. total ammonia nitrogen = 4.85 mg/L
Average total nitrogen over 30-day period = 1.14 mg N/L

5.2 Siltation TMDL

There is reasonable assurance that the goals of this TMDL can be met with proper watershed planning, aggressive implementation of storm water flow and pollutant reduction best management practices (BMPs), and strong political and financial mechanisms. Reasonable assurance that the TMDLs established for sediment will require a comprehensive, adaptive approach that addresses:

- point and nonpoint source pollution,
- existing and potential future sources,
- regulatory and voluntary approaches.

The 64 square mile Wissahickon Watershed comprises a variety of land uses from ultra urban to suburban to forest and parkland. The mainstem of the Creek traverses southeasterly for 24 miles through 16 Townships and several boroughs, from the headwaters in Lansdale to the mouth at the Schuylkill River in Philadelphia's Fairmount Park. The banks and surrounding land around the Wissahickon Creek vary as the Creek travels through each township and borough. The specific methods used to address high pollutant load reductions will vary with the land use along the particular segment of Creek. The methods used will also vary depending on the particular source of the pollutant load whether it is stream bank erosion from high flow conditions or overland flow which carries the pollutants from surrounding land.

The existing siltation problems in the Wissahickon watershed can be attributed to two main causes:

- <u>Stormwater Runoff</u> - Delivery of sediment to the stream carried by overland flow of stormwater (12.5% of total).

- <u>Instream Bank Erosion</u> - Sediment added to the water column because of stream bank erosion caused simply by the rapid delivery of a large volume of water to the stream during storms (88.5%of total). Frequent flashy storms which cause bankfull conditions result in significant erosion and scour of the stream bank

For purposes of allocating the loads, this TMDL report allocates the sediment fractions contributed by both instream bank erosion and overland flow as wasteload allocations. These wasteload allocations are characterized as such due to the fact that the Wissahickon watershed is found in an urbanized area that is regulated by the Federal National Pollutant Discharge Elimination System (NPDES) Program for stormwater as a municipal separate storm sewer system (MS4). While the loads can be grossly attributed to the municipal separate storm sewer systems as municipal point sources, the actual contribution of sediment may in some areas be due to "nonpoint sources" as well, including agricultural activities, forested lands, industrial activities, and other sources regulated and unregulated through the stormwater program.

The relative contribution of sediment by both sources varies throughout the watershed according to the distribution of land uses between urbanized and other sources, such as agriculture, and the amount of impervious cover in the watershed. Instream bank erosion is the most significant contributor. Therefore, reductions in the sediment entrained in overland flow must be accompanied by <u>substantial</u> reductions in the volume of water delivered to the stream in order to achieve the water quality objectives of the TMDL. Efforts must also be taken to control future potential sources of sediment and stormwater as new construction and redevelopment occurs. Because of the complexity of the problem and the potential solutions, an adaptive approach will be needed to achieve the TMDLs.

Pennsylvania's Approach to Control Stormwater

Both regulatory and nonregulatory approaches will be needed to achieve the necessary load reductions. Pennsylvania's program is being constructed to integrate State requirements under Act 167 for stormwater management planning, Federal requirements for permitting through the National Pollutant Discharge Elimination System (NPDES) program, and voluntary financial incentives provided to communities and project sponsors. Pennsylvania also recently adopted a *Comprehensive Stormwater Management Policy* (September 28, 2002)

Pennsylvania's *Comprehensive Stormwater Management Policy*

Stormwater management was identified as a priority in Pennsylvania during 15 water forums held throughout the State during 2001. As a result, DEP proposed a compressive stormwater management policy to more fully integrate post-construction stormwater planning requirements, emphasizing the use of ground water infiltration and volume and rate control best management practices (BMPs), into the National Pollutant Discharge Elimination System (NPDES) permitting program. The Policy also emphasizes the obligation under Pennsylvania's water quality standards (25 Pa. Code Section 93.4a) for stormwater management programs to maintain and protect existing uses and the level of water quality necessary to protect those uses.

Pennsylvania's *Stormwater Management Act of 1978* (Act 167)

In Pennsylvania, Act 167 requires each county to develop plans for each of its watersheds within its boundaries. This would be an excellent mechanism to properly plan watershed improvement projects in the Wissahickon. The watershed covered by an Act 167 Plan may cover a number of municipalities and could also cross county boundaries. Act 167 Plans must include provisions for improved water quality, groundwater recharge, post-construction storm water control standards, and stream bank protection strategies in addition to other storm water controls. In addition, a community must enact, administer, and enforce storm water ordinances within six months of PADEP's approval of the Act 167 Plans. Since 1985, Pennsylvania has been authorized to provided grants to counties up to 75% of costs of preparing the plans. Funds also authorized to provide municipalities with grants for implementation.

The Act 167 regulations specify that stormwater management plans be undertaken in two phases: Phase I, preparation of the Scope of Study; and Phase II, the actual plan preparation. Participation in Act 167 to date has been limited and most existing plans were developed to address flooding and not water quality. Pennsylvania is hopeful that participation in the program will increase now that more than 700 communities in Pennsylvania will need to have stormwater management plans in place to meet NPDES Program requirements. As of February 2003, 84 Act 167 plans have been completed by 46 counties, requiring 764 municipalities to implement ordinances. Also, 35 plans by 21 counties are underway (498 municipalities). To receive DEP approval, Act 167 plans must include water quality, groundwater recharge, post-construction stormwater control standards, and stream bank protection strategies in addition to stormwater quantity control. A community must enact, administer, and enforce its stormwater ordinances within six months of DEP approval. An Act 167 plan has not yet been prepared for the Wissahickon watershed.

Several benefits can accrue to communities who pursue Act 167 planning. As stated earlier, State funds are available for plan development. In addition, once a community has enacted its stormwater ordinances, the community may be eligible for PENNVEST Low Interest Loans to correct existing stormwater drainage problems. Projects may include transport, storage and infiltration of stormwater and best management practices to address point or nonpoint source pollution associated with stormwater.

Phase II Stormwater Permits or MS4s

Under the Federal National Pollutant Discharge Elimination System (NPDES) storm water program, operators of large, medium and regulated small municipal separate storm sewer systems (MS4s) require authorization to discharge pollutants under an NPDES permit. The NPDES permitting program is implemented by the Pennsylvania Department of Environmental Protection (DEP) under a delegation agreement with EPA.

Phase I of the Federal Stormwater NPDES Program began in 1990 and covered municipalities having a municipal separate storm sewer system (MS4) and having a population greater than 100,000 (including portions of Philadelphia). Phase I also extended to construction activities which disturbed more than 5 acres of land and to 11 categories of industrial activity. In Pennsylvania, the City of Philadelphia is one of two cities covered under the Phase I program.

Phase II implementation is underway. Phase II requirements for the Federal NPDES stormwater program were described in Federal regulations at 40 CFR 122(a)(16) issued in December 1999. Phase II extended the requirement to small MS4s in urbanized areas as defined by the 1990 and 2000 census data and for construction activities requiring stormwater permits reduced the threshold for the land area disturbed to one acre. As a result, the XX municipalities in the Wissahickon watershed are now being required to hold NPDES permits for stormwater. Maps identifying the urbanized area which includes the Wissahickon watershed and its political jurisdictions can be found on DEP's website at www.dep.state.pa.us under the directLINK stormwater.

MS4s were required to apply for permit coverage by March 10, 2003. The application must describe the stormwater management program they intend to implement, including a schedule, best management practices and measurable goals for each element of the municipal program. MS4 communities are required to implement a stormwater management program in their jurisdictions by the end of their 5-year permit term in March 2008. Pennsylvania issued a general permit to be used for MS4 permits (PAG-13). MS4s encompassing Special Protection watersheds in Pennsylvania will be covered through individual permits. The MS4 permittees in the Wissahickon watershed have all applied for permit coverage and their applications are under review.

Implementation of the Best Management Practices (BMPs) consistent with the stormwater management program and the “Minimum Control Measures” outlined in 40 CFR 132.34 is considered to constitute compliance with the standard of compliance, “maximum extent practicable” or MEP. To achieve reductions in stormwater discharges, EPA regulations establish six categories of “Minimum Control Measures” BMPs that must be met by permittees (these are "narrative" permit effluent limitations). The six BMP categories, also called "minimum control measures" in the Federal regulations, are:

1. Public education and outreach on stormwater impacts

2. Public involvement/participation consistent with state/local requirements in the development of a stormwater management plan.

3. Illicit discharge detection and elimination, including mapping of the existing stormwater sewer system(including at least the outfalls) and adoption of an ordinance to prohibit illicit connections and control erosion and sedimentation from development. .

4. Control of runoff from construction sites when one to five acres of land are disturbed. (Phase I covered sites larger than five acres.)

5. Post-construction stormwater monitoring and management in new development and redevelopment, and

6. Pollution prevention and good housekeeping for municipal operations and maintenance facilities

Under Phase II, permittees are also required to establish measurable goals for each BMP. Pennsylvania has also developed a “Protocol” which MS4s covered under the general permit can adopt to satisfy the requirements of the permit. MS4s can also choose to develop their own programs, but they must seek DEP approval. EPA has developed a National Menu of BMPs available for meeting the minimum control measures. Information can be found on EPA’s website at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/menu.cfm.

It is important to note that while many MS4 Phase II permits in Pennsylvania are expected to be issued as general permits with individual communities submitting Notices of Intent (NOIs), there are other avenues available. MS4 permits could be issued in the future on a watershed basis to improve stormwater management where multiple jurisdictions are responsible for a single watershed, as is the case in the Wissahickon, or where the approach can be specialized to focus on a pollutant of concern to all, such as sediment. A watershed permit could contain specialized requirements, provide the flexibility to facilitate pollutant trading to achieve results, and also provide economies of scale in plan development and implementation.

The Relationship of MS4 Permits to TMDLs

The MS4 communities in the Wissahickon watershed have received wasteload allocations for sediment. A November 22, 2002, EPA Memorandum entitled "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Stormwater Source and NPDES Permit Requirements Based on Those WLAs" clarified existing regulatory requirements for MS4s connected with TMDLs. The Memorandum also affirms EPA's view that an iterative adaptive management BMP approach is appropriate. Some of the major points raised in the Memorandum include the following:

- NPDES-regulated stormwater discharges must be considered in the TMDL as Wasteload allocations and may not be addressed by the load allocation component of the TMDL.
- Most water quality based effluent limitations for NPDES-regulated municipal and small construction stormwater discharges will be in the form of BMPs.
- Numeric limits will be used in permits only in rare instances.
- EPA expects WLAs and LA's in TMDLs to be in numeric form, although EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system.
- Stormwater discharges from sources that are <u>not</u> currently subject to NPDES requirements may be listed as LAs.
- The NPDES permit should specify monitoring necessary to comply with effluent limitations, to determine if expected load reductions from BMPs are expected to achieve the WLA in the TMDL, i.e., BMP performance data.
- The permit should also provide a mechanism to make adjustments to the required BMPs as necessary to insure adequate performance.

In order to carry out the NPDES program, DEP developed a General Permit for Stormwater Discharges from Small MS4s (PAG-13) to provide NPDES coverage to the more than 700 municipalities in Pennsylvania, which EPA reviewed and approved. As described by PAG-13, the MS4 permittee must, within the permit term, implement and enforce a stormwater management program approved by DEP which is designed to reduce the discharge of pollutants from its MS4 to the maximum extent practicable, with the goal of protecting water quality and satisfying the appropriate water quality requirements of the Federal Clean Water Act and the Pennsylvania Clean Streams Law. The program must contain a schedule, Best Management Practices (BMPs) and measurable goals for the six Minimum Control Measures as described in the Federal regulations and in PAG-13 and the program be approved by DEP. Communities who wholly or in part encompass Special Protection Watersheds are expected to apply for individual permits.

In accordance with Phase II NPDES Stormwater requirements, the municipalities in the Wissahickon watershed were required to apply for a permit by March 10, 2003 and are required to implement a stormwater management program by March 10, 2008. All have done so and their Notices of Intent are under review. PAG-13 outlines the following schedule for the next five years and includes the six minimum measures and measures of success.

<u>Watershed Planning</u>

The first step to effectively address the complex and varied nature of this part urban, part suburban, and rural watershed, is to develop a Watershed Management Plan which contains a plan of action for flow and pollutant load reduction and groundwater recharge. The Plan should address three major facets of watershed rehabilitation including 1) flow and pollutant reduction mechanisms (structural and nonstructural BMPs); 2) institutional mechanisms (Memorandum Of Agreements between municipalities and revised municipal ordinances); and 3) funding mechanisms (state and Federal grants, local utility fees etc.)

Flow and Pollutant Reduction Mechanisms - Storm Water BMPS

The major categories of BMPs that exist to reduce overland flow, promote groundwater recharge and reduce pollutant loads to streams include the following.

Nonstructural BMPs
- Public Education and Involvement
- Mapping of storm water utility
- Illicit discharge detection and elimination
- Good housekeeping practices

Structural BMPs
- Subsurface Storage
- Detention Ponds (with proper design)
- Infiltration Facilities
- Vegetative Filter Strips
- Wetlands and Bioretention
- Porous Pavement
- On-site runoff mechanism
- Low impact development

Urban areas with high percent impervious ground cover are often difficult places to incorporate many of the BMPs listed. Protecting water quality in these areas is difficult for many reasons including, diverse pollutant loads, large runoff volumes, limited areas suitable for surface water treatment systems, high implementation costs, and destruction of natural buffer zones adjacent to water bodies. There are however, numerous case studies and a growing amount of research that exists on this subject that indicates using a combination of BMPs to fit the constraints of urban areas can be successful in restoring water quality and recharging the groundwater. A detailed article about an urban retrofit in Seattle, WA may be found at http://seattlepi.nwsource.com/local/95881_model20.shtml A detailed description of storm water treatment practices to achieve Storm Water Phase II Retrofit in Madison, Wisconsin can be found on EPA's web site at www.epa.gov/owow/nps/natlstormwater03.

BMPs best suited for urban areas include: retrofit existing runoff management facilities to increase their size or promote enhanced infiltration, install trash capturing devices in the utilities, install inlet and grate inserts that trap oil and sediment, disconnect rather than eliminate impervious areas with vegetated buffers, infiltration devices or other pervious materials, install bioretention landscaping in parking lots, incorporate velocity dissipation devices such that the natural physical and biological characteristics and functions are maintained, etc. There is an approach for highly urbanized areas that has been developed by the EPA which is described in *National Management Measures to Control Nonpoint Source Pollution from Urban Areas*, December 2002, which would be an excellent resource for watershed restoration in portions of the Wissahickon. (www.epa.gov/owow/nps/urbanmm/index/htm) Additional watershed restoration resources (BMPs) are included following this discussion. Communities could also establish a program to evaluate existing stormwater sources and prioritize those for retrofits to maximize reductions in stormwater discharges. Additional information on the benefits of retrofits is available at www.stormwatercenter.org.

Institutional Mechanisms

Memorandum of Agreement (MOA) between municipalities
Municipal Ordinance that promotes preservation or restoration of natural hydrologic cycle
Building Codes that require Low Impact Development (LID)

MOAs can be established between Municipalities to work cooperatively and share resources. These types of MOAs have worked successfully in many parts of the country. Los Angeles, for instance has an agreement between 18 municipalities to implement the storm water regulations jointly. North Central Texas Council of Governments has an agreement with all townships in the Trinity Watershed to share outreach materials and contribute to one central website.

PADEP is finalizing a Model Ordinance for municipalities that operate "municipal separate storm sewer systems" (MS4s) that will be available in June 2003. This Model Ordinance can be adopted by municipalities or used as a guide in developing their own. The Model Ordinance sets forth provisions to prohibit nonstorm water discharges, erosion and sediment control plans, and requirements for post construction runoff from new development and redevelopment. The model Ordinance includes Low Impact Development techniques for storm water management within municipalities. The Model Ordinance is part of a guidance titled "Guidance on Model Ordinance Provisions" and will be available on PADEP web site in the summer of 2003.

Funding Mechanisms

Federal Grants (CWA Section 104(b)(3), CWA Section 319, State Revolving Fund)
State Grants (Act 167 grant, Growing Greener, PENNVEST)
Local storm water utility fees

One of the best and most readily available funding sources of those listed above is Pennsylvania's Stormwater Management Act, Act 167. Since 1985, Pennsylvania has been authorized to provide grants to counties up to 75% of costs of preparing the plans. Municipalities are provided similar grants for implementation. EPA funds are available through Pennsylvania under CWA Section 319 or the Nonpoint Source Program to fund some of those projects. As of November 27, 2002, 319 funds were also made available for activities relating to the implementation of the NPDES Storm Water Phase II program for FY 2003. At the time of writing of this TMDL, these Section 319 funds were being made available for FY 2004.

(President Bush signed into law on November 27, 2002 the *Great Lakes Legacy Act of 2002*, HR 1070, S 2544).

Growing Greener provides State funding and is by Pennsylvania as the mechanism to fund projects under Section 319. Growing Greener has provided funding for stormwater retrofits, demonstrated by grants to five entities in southeastern Pennsylvania last year to address stormwater. DEP's Southeastern Regional Office has also placed a high priority on activities to better control stormwater, reflecting the strong public interest in this area.

The attached table is a useful guide for funding sources available nationally and through the state. In addition to these grants and loans, Municipalities themselves have the option of developing storm water utility fees or to incorporate costs to operate storm water facilities in the water or sewer bill of residents.

Additional Watershed Restoration Resources - BMPs

1. National Menu of Best Management Practices for Storm Water Phase II (www.epa.gov/npdes/menuofbmps/menu.htm)

2. National Storm Water Best Management Practices (BMP) Database
www.bmpdatabase.org

3. Preliminary Data Summary of Urban Storm Water Best Management Practices, EPA document, August 1999, EPA-821-R-99-012, Washington, DC. (www.epa.gov/ost/stormwater)

BMP Options	Typical Sediment Removal (percent)
Retention Basins	50 - 80
Constructed Wetlands	50 - 80
Infiltration Basins	50 - 80
Infiltration Trenches/Dry Wells	50 - 80
Porous Pavement	65-100
Vegetated Filter Strips	50 - 80
Surface Sand Filters	50 - 80
Other Media Filters	65-100

4. EPA Chesapeake Bay Program document titled, "Storm Water Best Management Practice Categories and Pollutant Removal Efficiencies", updated March 10, 2003. (Chesapeake Bay Program's Urban Storm Water Workgroup, Annapolis, MD, www.chesapeakebay.net/uwg.htm, select "Current Projects and Information")

BMP Options	Typical Sediment Removal (percent)
Wet Ponds and Wetlands	80%
Filtering	85%
Infiltration	90%
Streambanks Restoration	2.55 lb/ft

<u>Additional Watershed Restoration Resources</u> - Funding Mechanisms

1. Growing Smarter Toolkit: Catalog of Financial and Technical Resource
A listing of current technical and financial assistance programs available in Pennsylvania. Each listing provides basic information on the program and a point of contact for more information
http://www.inventpa.com/docs/GrowingSmarterToolkit.pdf Or write to:
Governor's Center for Local and Governmental Services, Dept of Community and Economic Development, 400 North St, 4th Floor, Commonwealth Keystone Bldg, Harrisburg, PA 17120
This resource includes links to Pennsylvania's Growing Greener Grant Program at www.dep.state.pa.us/growgreen/

2. The Catalog of Federal Domestic Assistance
This web site gives you access to a database of all Federal programs available to State and local governments (including the District of Columbia); Federally-recognized Indian tribal governments; Territories (and possessions) of the United States; domestic public, quasi-public, and private profit and nonprofit organizations and institutions; specialized groups; and individuals.
http://www.cfda.gov/

3. An Internet Guide to Financing Storm water Management This guide addresses the complex series of questions that managers must answer when developing plans to pay for storm water programs. For example:
– How much revenue will we need?
– What are the alternative ways to generate revenue?
– How can we match sources to needs?
– How much are people willing to pay?

This guide is a compilation of effective funding tools that has evolved during the past 25 years as public managers have developed interesting, innovative approaches to paying for runoff programs.
http://stormwaterfinance.urbancenter.iupui.edu/

Important Note #1: The Center for Urban Policy and the Environment as well as the American Waterworks Association are also excellent reference points of contact for information on funding. They have extensive lists of contacts and papers explaining how other cities and towns have worked through the Storm Water Phase II implementation.

Important Note #2 : Studies show that municipal storm water management can cost residents on average between $6.00 to $22.00 a year in increased fees.

SOURCES OF NPDES STORM WATER FUNDING FOR STATE AND LOCAL GOVERNMENTS

Name of Grant/ Source of Funding	Brief Description	Eligibility	Contact/How to Apply	Amount of Funding Available	Application Deadline
Chesapeake Bay Small Watershed Grants Program	Grants for work at the local level to protect and improve watersheds in the Chesapeake Bay Watershed.	local governments and non-profits	National Fish and Wildlife Foundation, 1120 Connecticut Ave, NW, Suite 900, Washington, DC 20036 http://www.nfwf.org/programs/chspke_app.htm – Jonathan Mawdsley (202) 857-0166	Total $2½ million – typical grant is around $25,000	Annually on February 1st
Five Star Restoration Challenge Grant Program	Grants for community based wetland, riparian and coastal habitat restoration projects	Local governments and non-profits	National Fish and Wildlife Foundation, 1120 Connecticut Ave, NW, Suite 900, Washington, DC 20036 http://www.nfwf.org/programs/5star-rfp.htm – Tom Kelsh (202) 857-0166	Average grant is $10,000	Annually on March 1st
Economic Development Administration, US Dept of Commerce	Project grants to assist in the construction of public works in areas experiencing substantial economic distress. For description of program: http://www.cfda.gov/static/p11300.htm	States, cities, counties, institutions of higher education, and Economic Development Districts, and private or public nonprofit organizations or associations	Applicants MUST contact the EDR servicing the State in which the project is located or other designated EDA Official. The economic development representative or other appropriate EDA Official assigned as coordinator for the project will provide necessary forms and assistance to interested applicants Philadelphia Regional Office http://www.osec.doc.gov/eda/html/1a11_1e_philadelphia.htm Curtis Center, Suite 140 South Independence Square West Philadelphia, PA 19106-3821 215-597-4603 Paul M. Raetsch, Regional Director praetsch@eda.doc.gov	On average, EDA grants cover approx 50 % of project costs.	No fixed deadline

Name of Grant/ Source of Funding	Brief Description	Eligibility	Contact/How to Apply	Amount of Funding Available	Application Deadline
Coastal Zone Management **(CZM)** and Coastal Nonpoint Pollution Program **(CNPP)** Grants	These grants fund local projects that enhance the capabilities of local organizations to prevent nonpoint source pollution, including storm water	State agencies, local government, regional agencies, and nonprotfit groups	Application forms can be obtained from the Delaware Valley Regional Planning Commission (DVRPC) web page at http://www.dvrpc.org/planning/czm/AppGuide2002Rev.pdf Jim Nagy, Coastal Zone Management Program at 717-783-2402, email: jnagy@state.pa.us.	$20,000-$40,000 (max $50,000)	9/27/02 (annually in September)
Clean Water Act Section 104(b)(3), EPA Headquarters	Project grants for unique & innovative projects that address the requirements of the NPDES program. Please note this is a competitive process.	State water pollution control agencies, interstate agencies, Tribes, colleges and universities, and other public or nonprofit organizations	www.epa.gov/owm/cwfinance/index.htm	Range/Average of Financial Assistance - $5,000 to $500,000 per project	Not posted for FY '03
Clean Water Act Section 106	To assist States/Interstate agencies in establishing & maintaining adequate programs and measures for prevention and control of surface & ground water pollution.	State and Interstate water pollution control agencies	State Applications should be sent to EPA, Region III, Grants Audit & Management Branch.	Amount to each State determined by a national formula	August 1, 2002 for FY '03 Grants

Name of Grant/ Source of Funding	Brief Description	Eligibility	Contact/How to Apply	Amount of Funding Available	Application Deadline
Pennsylvania Infrastructure Investment Authority (**PENNVEST**)	Low interest loans for design, engineering, and construction of municipal storm water and conveyance and control systems, drinking water facilities, and wastewater systems. **NOTE**: Any municipality, authority or private entity that is eligible under a **PENNVEST** project will be automatically considered for **PENNVEST** Growing Greener grant funds.	Any owner and/or operator of a water, sewer or municipal storm-water system.	http://www.pennvest.state.pa.us/pennvest/cwp/view.asp?A=4&Q=72530 contact: Beverly Reinhold (717) 783-6589 breinhold@state.pa.us	loan amount of up to 100% of total project cost, based on need; ; amount of loan varies - up to $11 million per project for one municipality - up to $20 million for more than one municipality	no set deadline
Watershed Restoration and Protection Grants **(PADEP)**	Grants for watershed restoration and protection (e.g., abandoned mine drainage and urban and agricultural runoff)	Municipalities, watershed associations, conservation districts, nonprofit groups	www.dep.state.pa.us/growgreen http://www.dep.state.pa.us/growgreen/watershedprotection/FactSheets/G2factsheet.pdf NOTE: applicants MUST discuss their project with a watershed manager prior to submitting application. 717-705-5400	$55 million annually statewide	2/3/03 (tentative) and annually thereafter
DEP Storm water Management Program	The storm water management program administers a grant program under the Storm Water Management Act (Act 167) for counties to prepare watershed plans to manage storm water runoff from new land development activities. Plans are implemented by municipalities through the enactment or amendment of local ordinances.		http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement.htm Durla Lathia PADEP P.O. Box 8555 Harrisburg, PA 17105 email: dlathia@state.pa.us	$1.2 million annually statewide	

6.0 Public Participation

Public participation is not only a requirement of the TMDL process, but is essential to its success. At a minimum, the public must be allowed at least 30 days to review and comment prior to establishing a TMDL. Also, EPA must provide a summary of all public comments and responses to those comments to indicate how the comments were considered in the final decision.

Multiple publicly held meetings have been provided throughout all stages of the project to inform and update the public on all aspects of the project as it evolved. The public was encouraged to participate in data collection efforts and provide comments to a report of the data review and proposed TMDL methodology prior to TMDL development. In addition, EPA provided the public the unique opportunity to suggest modeling scenarios prior to TMDL development. As a result, several suggestions of stakeholders were included in TMDL development. The following provides a chronology of opportunities for public participation provided throughout the project:

October 23, 2001	Public meeting to discuss overview of Wissahickon Creek impairments, objectives of TMDLs, and alternative methodologies for TMDL development.
January 4, 2002	Draft *Data Review for Wissahickon Creek, Pennsylvania* was provided to public for comment
January 17, 2002	Public meeting to discuss selected methodologies for TMDL development
March 1, 2002	Final *Data Review for Wissahickon Creek, Pennsylvania* and responses to public comment were provided to stakeholders; as requested, stakeholders were provided a list of data collection to assist in TMDL development.
April 4, 2002	Public meeting to discuss (1) data collection for nutrient TMDL development and (2) reference watershed selection.
November 4, 2002	Public meeting to discuss (1) results of summer 2002 data collection, (2) preliminary results of model calibration for nutrient TMDL development, and (3) the selected reference watershed
November 7, 2002	Letter to stakeholders inviting suggestions regarding model scenarios to be tested nutrient TMDL development (scenarios due by November 18)
February 10, 2003	Public notice of draft *Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania* (comment period ending March 14)

March 4 & 5, 2003	Two public meetings providing presentation of nutrient and siltation TMDL results; addendum to draft *Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania* provided.
March 11, 2003	Draft *Modeling Report for Wissahickon Creek, Pennsylvania Nutrient TMDL Development* provided to stakeholders to assist in technical review of model.
March 14, 2003	Comment period extended to March 28, 2003.
June 9, 2003	Public notice of second draft *Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania* with responses to comments of first draft.

In addition to the events outlined above, EPA met with stakeholders on several occasions throughout and after the public comment period of the first draft *Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania* to discuss options for nutrient TMDLs. These meetings provided stakeholders' opportunity to question EPA's contractor during technical review of the models and provided EPA with insight regarding model scenarios that could be tested for development of WLAs.

Following public comment, the draft *Modeling Report for Wissahickon Creek, Pennsylvania Nutrient TMDL Development*, the low-flow model utilized for development of nutrient TMDLs was revised to address concerns of stakeholders. Likewise, specific issues were addressed regarding calculation of siltation TMDLs. Due to the extent of modifications to the analytical framework resulting in subsequent changes in TMDL results and WLAs, the TMDL Report was re-opened for public comment on June 9th, 2003.

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